



ΕΛΛΗΝΙΚΗ  
ΕΠΙΣΤΗΜΟΝΙΚΗ  
ΕΤΑΙΡΕΙΑ  
ΕΔΑΦΟΜΗΧΑΝΙΚΗΣ  
& ΓΕΩΤΕΧΝΙΚΗΣ  
ΜΗΧΑΝΙΚΗΣ

# Τα Νέα

64

## της Ε Ε Ε Ε Γ Μ

### Διεθνής διάκριση για τη Σχολή Πολιτικών Μηχανικών του ΕΜΠ

Η Σχολή Πολιτικών Μηχανικών παραμένει και το 2014 σε εξαιρετική θέση στην ιεράρχηση των αντίστοιχων Σχολών του κόσμου από τα πασίγνωστα έγκριτα QS World University Rankings.

Σε μια ιδιαίτερα δύσκολη για τη χώρα περίοδο και σε συνθήκες εντεινόμενου παγκόσμιου ανταγωνισμού η Σχολή διατηρείται το 2014 στην θέση 7 σε Ευρωπαϊκό επίπεδο και στην θέση 28 παγκοσμίως.

Τα κριτήρια αξιολόγησης στα οποία στηρίζονται τα [QS World University Rankings](#) είναι η ακαδημαϊκή αναγνώριση, που αντικατοπτρίζει την ένταση της επιστημονικής παρουσίας των μελών της Σχολής, η επαγγελματική αναγνώριση, που επιβεβαιώνει την αυξημένη τεχνική και επιστημονική εγκράτεια των αποφοίτων, και ο αριθμός των αναφορών σε δημοσιευμένες εργασίες, που αντανακλά το εύρος και την πρωτοτυπία του παραγόμενου επιστημονικού έργου στη Σχολή.

Η ποσοτικοποίηση των δύο πρώτων κριτηρίων, γίνεται με βάση απαντήσεις εκατοντάδων στελεχών πανεπιστημίων και εταιρειών αντίστοιχα ανά τον κόσμο, ενώ η ποσοτικοποίηση του τρίτου κριτηρίου, στο οποίο η Σχολή του ΕΜΠ έρχεται 1η στην Ευρώπη και 3η στον κόσμο, γίνεται με αντικειμενικό τρόπο μέσα από κατάλληλες ηλεκτρονικές και διαδικτυακές διαδικασίες.

Ο Γιάννης Γκόλιας, καθηγητής ΕΜΠ και κοσμήτορας της Σχολής Πολιτικών Μηχανικών, τόνισε πως "πρόκειται για μια πολύ μεγάλη επιτυχία της Σχολής Πολιτικών Μηχανικών ΕΜΠ,

(συνέχεια στην σελ.3)

Αρ. 64 – ΜΑΙΟΣ 2014



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(συνέχεια από την πρώτη σελίδα)

που βασίζεται στη μετά από έντονες πολυετείς προσπάθειες εξασφάλιση και διατήρηση συλλογικής αριστείας στον εκπαιδευτικό και τον ερευνητικό τομέα και ουσιαστικής αποτελεσματικότητας στον διοικητικό τομέα".

Όπως σημείωσε: "Τελικό αποτέλεσμα η εξέχουσα κατάρτιση των αποφοίτων της Σχολής, οι οποίοι κατατάσσονται και επισήμως ως προς την επαγγελματική τους εγκράτεια όγδοοι στην Ευρώπη και τριακοστοί σε παγκόσμιο επίπεδο.

Η επιτυχία αυτή παίρνει ιδιαίτερες διαστάσεις αν ληφθεί υπόψη ότι οι προϋπολογισμοί των Σχολών που προηγούνται είναι σημαντικά πολλαπλάσιοι εκείνου της Σχολής του ΕΜΠ".

Ο Γιάννης Γκόλιας επεσήμανε πως "πρόκειται για μια μεγάλη επιτυχία του ΕΜΠ, που απαντά αποστομωτικά σε όλους τους αμφισβητούντες το ελληνικό πανεπιστήμιο, εντός και εκτός Ελλάδας, και καταρρίπτει και πάλι τον μύθο της "ψωροκώσταινας".

Μέσα στο περιβάλλον απαισιοδοξίας και γκρίνιας που μας περιβάλλει, το ελπιδοφόρο μήνυμα που εκπέμπεται προκύπτει με σαφήνεια: Μπορούμε όλοι ψηλότερα! Η Ελλάδα μπορεί!"

(EURO2day, 13.03.2014,  
<http://www.euro2day.gr/news/highlights/article-news/1192993/diethnhs-diakrish-gia-th-sholh-politikon-mhhanikon.html#.UyGO5w-HZCM.email>)

**QS World University Rankings by Subject 2014 - Engineering - Civil & Structural**

Overall Score	UNIVERSITY	Academic Reputation	Employer Reputation	Citations per Paper	H-index Citations
1 <sup>87.0</sup>	<u>Massachusetts Institute of Technology (MIT)</u>	4 <sup>86.5</sup>	10 <sup>93.4</sup>	26 <sup>77.4</sup>	17 <sup>79.7</sup>
2 <sup>86.8</sup>	<u>University of Illinois at Urbana-Champaign</u>	1 <sup>100.0</sup>	49 <sup>64.4</sup>	8 <sup>84.0</sup>	7 <sup>90.0</sup>
3 <sup>85.7</sup>	<u>University of California, Berkeley (UCB)</u>	3 <sup>87.3</sup>	30 <sup>83.0</sup>	5 <sup>86.1</sup>	10 <sup>85.1</sup>
4 <sup>83.9</sup>	<u>The University of Tokyo</u>	9 <sup>80.3</sup>	13 <sup>91.9</sup>	19 <sup>79.7</sup>	13 <sup>82.5</sup>
4 <sup>83.9</sup>	<u>University of Cambridge</u>	11 <sup>78.1</sup>	1 <sup>100.0</sup>	37 <sup>71.6</sup>	26 <sup>76.6</sup>
6 <sup>83.8</sup>	<u>University of Texas at Austin</u>	2 <sup>90.1</sup>	37 <sup>76.1</sup>	22 <sup>78.9</sup>	17 <sup>79.7</sup>
7 <sup>83.6</sup>	<u>National University of Singapore (NUS)</u>	19 <sup>75.8</sup>	4 <sup>97.1</sup>	6 <sup>85.9</sup>	17 <sup>79.7</sup>
8 <sup>83.1</sup>	<u>Kyoto University</u>	7 <sup>82.5</sup>	17 <sup>89.5</sup>	29 <sup>76.6</sup>	31 <sup>73.4</sup>
9 <sup>82.8</sup>	<u>Imperial College London</u>	5 <sup>83.4</sup>	28 <sup>83.8</sup>	12 <sup>82.7</sup>	26 <sup>76.6</sup>
10 <sup>82.3</sup>	<u>University of Hong Kong</u>	23 <sup>74.2</sup>	9 <sup>93.9</sup>	4 <sup>90.8</sup>	17 <sup>79.7</sup>
11 <sup>82.2</sup>	<u>Stanford University</u>	8 <sup>80.8</sup>	14 <sup>90.4</sup>	34 <sup>73.6</sup>	31 <sup>73.4</sup>
12 <sup>81.9</sup>	<u>The Hong Kong University of Science and Technology</u>	20 <sup>75.6</sup>	3 <sup>98.6</sup>	38 <sup>71.5</sup>	31 <sup>73.4</sup>
13 <sup>81.0</sup>	<u>ETH Zurich (Swiss Federal Institute of Technology)</u>	12 <sup>77.1</sup>	19 <sup>89.3</sup>	21 <sup>79.5</sup>	26 <sup>76.6</sup>
14 <sup>80.6</sup>	<u>Delft University of Technology</u>	15 <sup>76.6</sup>	25 <sup>85.6</sup>	22 <sup>78.9</sup>	9 <sup>87.6</sup>
15 <sup>80.0</sup>	<u>The Hong Kong Polytechnic University</u>	31 <sup>66.7</sup>	21 <sup>88.7</sup>	1 <sup>100.0</sup>	1 <sup>100.0</sup>
15 <sup>80.0</sup>	<u>The University of Sydney</u>	17 <sup>76.2</sup>	20 <sup>89.0</sup>	31 <sup>75.5</sup>	26 <sup>76.6</sup>
17 <sup>79.3</sup>	<u>Politecnico di Milano</u>	26 <sup>71.6</sup>	8 <sup>94.0</sup>	11 <sup>82.8</sup>	40 <sup>69.8</sup>
18 <sup>78.4</sup>	<u>The University of New South Wales</u>	24 <sup>74.1</sup>	15 <sup>89.9</sup>	26 <sup>77.4</sup>	45 <sup>65.9</sup>
19 <sup>77.9</sup>	<u>University of Canterbury</u>	16 <sup>76.3</sup>	23 <sup>87.9</sup>	44 <sup>63.1</sup>	40 <sup>69.8</sup>
20 <sup>77.8</sup>	<u>Tsinghua University</u>	38 <sup>63.0</sup>	5 <sup>95.7</sup>	10 <sup>83.7</sup>	3 <sup>92.2</sup>
21 <sup>77.6</sup>	<u>Nanyang Technological University (NTU)</u>	32 <sup>66.4</sup>	7 <sup>94.8</sup>	41 <sup>80.1</sup>	17 <sup>79.7</sup>
21 <sup>77.6</sup>	<u>Tongji University</u>	10 <sup>79.8</sup>	43 <sup>72.0</sup>	21 <sup>68.4</sup>	21 <sup>92.2</sup>
23 <sup>77.2</sup>	<u>Purdue University</u>	6 <sup>82.8</sup>	48 <sup>65.2</sup>	13 <sup>82.5</sup>	17 <sup>79.7</sup>
24 <sup>75.9</sup>	<u>Ecole Polytechnique Fédérale de Lausanne</u>	29 <sup>68.6</sup>	22 <sup>88.2</sup>	25 <sup>77.6</sup>	31 <sup>73.4</sup>
24 <sup>75.9</sup>	<u>Georgia Institute of Technology</u>	21 <sup>74.7</sup>	42 <sup>72.7</sup>	24 <sup>81.9</sup>	10 <sup>85.1</sup>

26 <sup>75.8</sup>	<u>Texas A&amp;M University</u>	18 <sup>76.1</sup>	47 <sup>68.7</sup>	28 <sup>76.9</sup>	2 <sup>94.3</sup>
27 <sup>75.5</sup>	<u>University of California, San Diego (UCSD)</u>	13 <sup>76.9</sup>	46 <sup>69.0</sup>	16 <sup>81.0</sup>	13 <sup>82.5</sup>
28 <sup>74.2</sup>	<u>National Technical University of Athens</u>	42 <sup>60.7</sup>	27 <sup>84.7</sup>	3 <sup>94.6</sup>	7 <sup>90.0</sup>
29 <sup>73.9</sup>	<u>Tokyo Institute of Technology</u>	27 <sup>69.8</sup>	29 <sup>83.4</sup>	42 <sup>66.5</sup>	31 <sup>73.4</sup>
30 <sup>73.8</sup>	<u>Monash University</u>	37 <sup>63.1</sup>	12 <sup>92.9</sup>	32 <sup>74.2</sup>	40 <sup>69.8</sup>
31 <sup>73.0</sup>	<u>City University of Hong Kong</u>	44 <sup>59.8</sup>	32 <sup>80.0</sup>	2 <sup>99.1</sup>	3 <sup>92.2</sup>
32 <sup>72.5</sup>	<u>KAIST - Korea Advanced Institute of Science &amp; Technology</u>	32 <sup>66.4</sup>	32 <sup>80.0</sup>	30 <sup>76.2</sup>	26 <sup>76.6</sup>
33 <sup>71.7</sup>	<u>University of Toronto</u>	30 <sup>68.4</sup>	44 <sup>71.4</sup>	15 <sup>81.3</sup>	17 <sup>79.7</sup>
34 <sup>71.6</sup>	<u>University of California, Davis</u>	22 <sup>74.6</sup>	50 <sup>59.4</sup>	20 <sup>79.6</sup>	10 <sup>85.1</sup>
35 <sup>71.2</sup>	<u>National Taiwan University (NTU)</u>	40 <sup>61.3</sup>	24 <sup>86.1</sup>	33 <sup>74.1</sup>	31 <sup>73.4</sup>
36 <sup>71.1</sup>	<u>Universitat Politècnica de Catalunya</u>	28 <sup>69.7</sup>	45 <sup>70.9</sup>	40 <sup>70.1</sup>	17 <sup>79.7</sup>
37 <sup>71.0</sup>	<u>Cornell University</u>	25 <sup>72.8</sup>	40 <sup>74.9</sup>	46 <sup>60.0</sup>	47 <sup>61.6</sup>
38 <sup>70.8</sup>	<u>Seoul National University</u>	47 <sup>58.6</sup>	17 <sup>89.5</sup>	35 <sup>73.3</sup>	31 <sup>73.4</sup>
39 <sup>70.6</sup>	<u>University of Oxford</u>	40 <sup>61.3</sup>	1 <sup>100.0</sup>	48 <sup>48.5</sup>	48 <sup>51.3</sup>
40 <sup>70.4</sup>	<u>Karlsruhe Institute of Technology (KIT)</u>	34 <sup>65.7</sup>	39 <sup>75.6</sup>	24 <sup>78.6</sup>	50 <sup>69.8</sup>
41 <sup>70.2</sup>	<u>Politecnico di Torino</u>	49 <sup>56.0</sup>	26 <sup>85.1</sup>	9 <sup>83.8</sup>	13 <sup>82.5</sup>
42 <sup>70.1</sup>	<u>California Institute of Technology (Caltech)</u>	13 <sup>76.9</sup>	31 <sup>80.6</sup>	50 <sup>30.0</sup>	45 <sup>45.0</sup>
42 <sup>70.1</sup>	<u>The University of Queensland</u>	46 <sup>58.9</sup>	6 <sup>95.4</sup>	42 <sup>54.7</sup>	42 <sup>65.9</sup>
44 <sup>69.5</sup>	<u>The University of Melbourne</u>	36 <sup>64.2</sup>	11 <sup>93.2</sup>	49 <sup>43.5</sup>	48 <sup>51.3</sup>
45 <sup>69.4</sup>	<u>The University of Newcastle</u>	35 <sup>65.1</sup>	36 <sup>78.9</sup>	45 <sup>61.4</sup>	40 <sup>69.8</sup>
46 <sup>69.2</sup>	<u>KTH, Royal Institute of Technology</u>	48 <sup>56.1</sup>	34 <sup>79.6</sup>	17 <sup>80.8</sup>	3 <sup>92.2</sup>
47 <sup>68.9</sup>	<u>Queensland University of Technology</u>	50 <sup>54.9</sup>	16 <sup>89.6</sup>	36 <sup>72.1</sup>	31 <sup>73.4</sup>
48 <sup>68.7</sup>	<u>Technical University of Denmark</u>	45 <sup>59.2</sup>	41 <sup>74.6</sup>	7 <sup>84.2</sup>	13 <sup>82.5</sup>
49 <sup>68.6</sup>	<u>Indian Institute of Technology Madras (IITM)</u>	39 <sup>62.8</sup>	38 <sup>75.9</sup>	39 <sup>70.8</sup>	31 <sup>73.4</sup>
50 <sup>68.5</sup>	<u>Indian Institute of Technology Bombay (IITB)</u>	43 <sup>60.1</sup>	35 <sup>79.6</sup>	43 <sup>66.3</sup>	17 <sup>79.7</sup>

The ***h-index*** is an index that attempts to measure both the productivity and impact of the published work of a scientist or scholar. The index is based on the set of the scientist's most cited papers and the number of citations that they

have received in other publications. The index can also be applied to the productivity and impact of a group of scientists, such as a department or university or country, as well as a scholarly journal.



## Massive landslide at Utah copper mine generates wealth of geophysical data

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### ABSTRACT

On the evening of 10 April 2013 (MDT) a massive landslide occurred at the Bingham Canyon copper mine near Salt Lake City, Utah, USA. The northeastern wall of the 970-m-deep pit collapsed in two distinct episodes that were each sudden, lasting ~90 seconds, but separated in time by ~1.5 hours. In total, ~65 million cubic meters of material was deposited, making the cumulative event likely the largest non-volcanic landslide to have occurred in North America in modern times. Fortunately, there were no fatalities or injuries. Because of extensive geotechnical surveillance, mine operators were aware of the instability and had previously evacuated the area. The Bingham Canyon mine is located within a dense regional network of seismometers and infrasound sensors, making the 10 April landslide one of the best recorded in history. Seismograms show a complex mixture of short- and long-period energy that is visible throughout the network (6–400 km). Local magnitudes (ML) for the two slides, which are based on the amplitudes of short-period waves, were estimated at 2.5 and 2.4, while magnitudes based on the duration of seismic energy ( $m_d$ ) were much larger ( $>3.5$ ). This magnitude discrepancy, and in particular the relative enhancement of long-period energy, is characteristic of landslide seismic sources. Interestingly, in the six days following the landslide, 16 additional seismic events were detected and located in the mine area. Seismograms for these events have impulsive arrivals characteristic of tectonic earthquakes. Hence, it appears that in this case the common geological sequence of events was inverted: Instead of a large earthquake triggering landslides, it was a landslide that triggered several small earthquakes.

### INTRODUCTION

Landslides are among the most destructive geological forces in nature, causing billions of dollars in damage annually (see [landslides.usgs.gov](http://landslides.usgs.gov) [USGS, 2013]). For the period of 2004–2011, more than 32,000 landslide-related fatalities have been documented, not including those landslides caused by earthquakes (Petley, 2012). Here, we describe a recent massive landslide in Utah that was successfully forecast and thus resulted in no fatalities or injuries. Furthermore, it occurred within a dense regional network of seismic and acoustic sensors, generating a valuable and unique data set for studying landslide physics.

### THE BINGHAM CANYON LANDSLIDE

The landslide occurred on 10 April 2013 at the Bingham Canyon open-pit copper mine, located in the Oquirrh Mountains ~33 km southwest of downtown Salt Lake City, Utah, USA (Fig. 1A). Leaving a massive scar on the upper half of the northern pit wall, the slide filled the mine floor with thick debris (Fig. 1B). The long runout and distinctive flow-like character of the deposit suggest that the event was a particular type of extremely rapid mass movement known as a rock avalanche (Hungr et al., 2001).

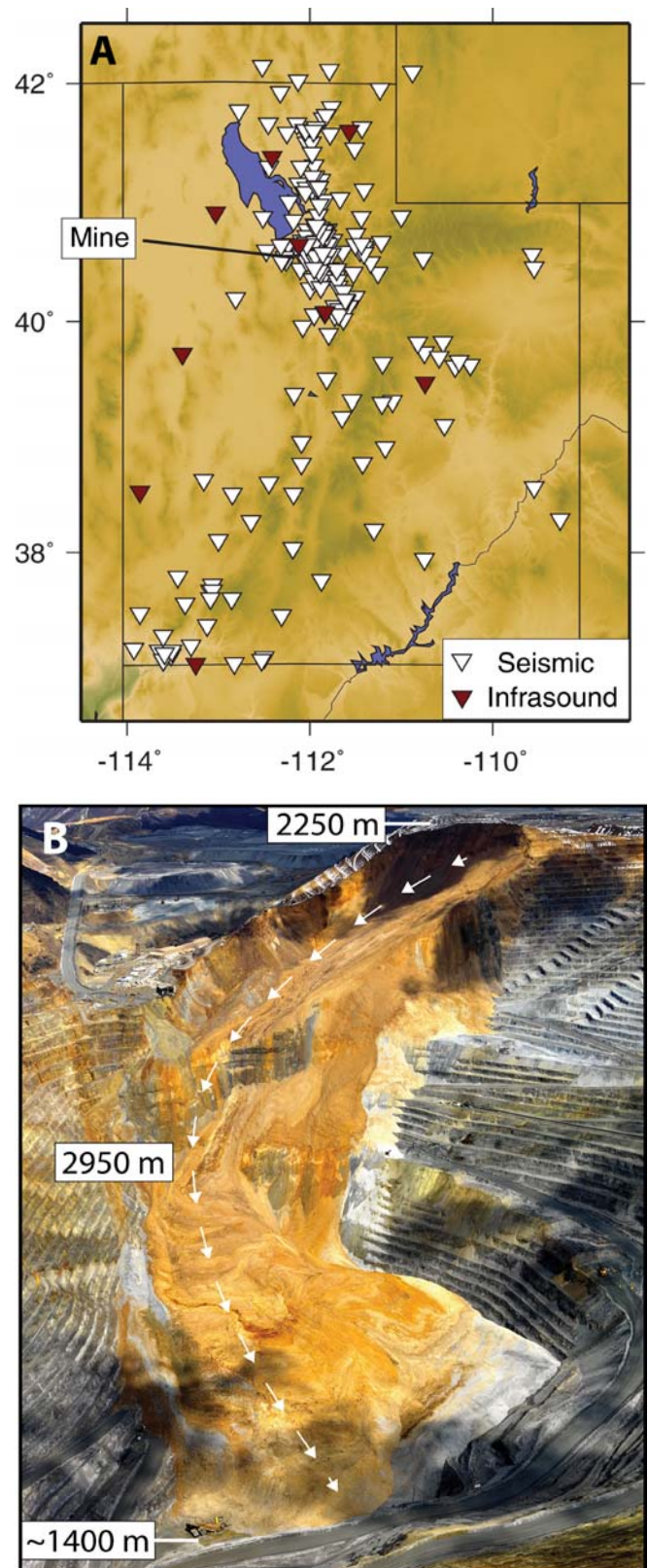


Figure 1. (A) University of Utah seismic and infrasound network, and location of the Bingham Canyon mine. (B) Photograph of the 10 April 2013 rock avalanche (copyright Kennecott Utah Copper, used with permission). Elevation of the crest and toe of the slide are shown, as well as an estimate of the runout distance along the arcuate travel path. A group of large haul trucks damaged by the slide can be seen at lower left.

At more than 970 m deep, Kennecott's Bingham Canyon mine is the largest man-made excavation in the world. It has been in operation since 1906 and produces 25% of the copper used in the United States. The site has produced

more copper than any mine in history. For decades, mine operators have monitored the stability of pit slopes within the Bingham Canyon mine, operating a surveillance network that includes the latest techniques in early-warning monitoring, such as automated geodetic networks, in situ extensometers, and ground-based radar interferometry (e.g., Gischig et al., 2011). These monitoring systems proved crucial in first identifying, and then monitoring, the displacement of the incipient landslide on the northeastern wall of the Bingham Canyon mine.

Signs of increasing instability were evident throughout early 2013 as displacements accelerated within the unstable area. A visitor center, which had been located within the landslide source region, was closed and removed. Ultimately, on 10 April, movements became so strong that mine operators evacuated the area and issued a press release stating that failure was imminent and rising dust might become visible. The first rock avalanche occurred roughly seven hours later at 9:30 p.m. MDT. Because the area had been evacuated, there were no injuries; however, several pieces of heavy equipment and critical infrastructure were damaged or impacted. These included 14 haul trucks, three shovels, and the forced closure of the pit's main access ramp.

Comparing digital elevation models from before and after the event, Kennecott estimated the landslide moved a total mass of 165 million tons (Kennecott Utah Copper, 2013), equivalent to a source volume of roughly 55 million cubic meters. As the source rock breaks up, it expands, typically by 10%–30%, so the deposit volume was likely in the range of 65 million cubic meters. For comparison, the deposit would cover New York City's Central Park with ~20 m of debris. These volumes make the Bingham Canyon rock avalanche likely the largest non-volcanic landslide in North American history, eclipsing the recent 2012 Lituya Bay rock avalanche in Alaska (volume <50 million m<sup>3</sup>), the 2010 Mount Meager rock slide/debris flow in British Columbia (48 million m<sup>3</sup>), the 1965 Hope rock slide in British Columbia (47 million m<sup>3</sup>), the 1959 Madison River Canyon landslide in Montana (30 million m<sup>3</sup>), and the 1903 Frank slide in the Northwest Territories of Canada (30 million m<sup>3</sup>). In North America and worldwide, rock avalanches of this size routinely claim lives; the Madison River Canyon slide killed 28, the Frank slide killed up to 90, while the 2009 Xiaolin landslide in Taiwan (25 million m<sup>3</sup>) caused nearly 500 fatalities. These statistics highlight the potentially devastating consequences of catastrophic rock avalanches and emphasize the importance of early-warning monitoring systems, such as those used at the Bingham Canyon mine.

Rock avalanches are distinguished from other types of landslides by their massive volume and characteristically fast and long runout. While rock fall debris, for example, accumulates at steep inclinations close to the angle of repose, rock avalanche deposits can spread over many kilometers, leaving gently inclined, characteristically hummocky terrain containing highly crushed and fragmented, yet compact, debris. Typical flow velocities are in the range of tens of meters per second and can reach as high as 100 m/s (e.g., Crosta et al., 2004). In the past, such runout was often thought to be anomalous, but today we know it is common for source volumes of this size that fail in a catastrophic manner, although the precise mechanisms driving rock avalanche dynamics are still debated (Davies and McSaveney, 2012). Comparing the geometry (fall height and length) of the Bingham Canyon rock avalanche with other events from across the globe shows that, at roughly 2950 m, the total travel distance from crest to toe is within the expected range for events of this size (Fig. 2). The slide would likely have run farther had it not impacted the southern pit wall. Considerable variability exists within the global data set, however, and precise prediction of runout distance, even with the aid of numerical modeling, is challenging.

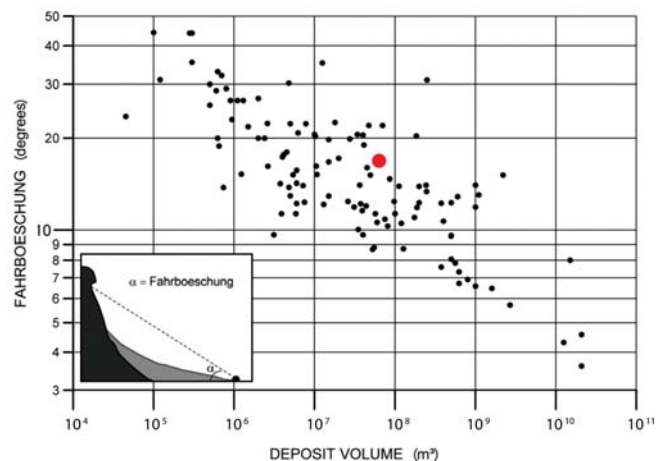


Figure 2. Comparison of the Bingham Canyon rock avalanche (red dot) with other reported landslide events from across the globe (figure modified from Bourrier et al., 2013, with data from C. Davidson, unpublished M.Eng. thesis, 2011). The estimated geometry results in a Fahrboeschung value (defined as the angle relating the fall height and length) of 16°, which is within the expected range for events of this size.

Local news agencies reported initial cost estimates related to the Bingham Canyon rock avalanche approaching one billion dollars. If these estimates prove correct, the rock avalanche will become the most expensive landslide in U.S. history, surpassing the 1983 Thistle slide (also in Utah), which at the time was estimated to have cost between 460 and 940 million dollars (values adjusted for inflation). For now, the successful monitoring and hazard mitigation are heralded as an achievement, as well as an example to others facing the danger of catastrophic rock slope failures.

#### SEISMIC AND INFRASOUND RECORDINGS OF THE LANDSLIDE

The University of Utah Seismograph Stations (UUSS) has operated a seismic network in the Utah region (Fig. 1A) since the early 1960s (Pechmann et al., 2007; Thomas et al., 2013) with the goal of detecting, locating, and characterizing regional earthquakes associated with the Intermountain Seismic Belt (Smith and Arabasz, 1991). The network is a Tier I component of the Advanced National Seismic System (ANSS) of the U.S. Geological Survey (USGS, 1999) and is funded via a state-federal partnership. As of 1 April 2013, the Utah network consisted of 200 seismographs, including broadband, accelerometer, and short-period sensors, generating 667 channels of 100 Hz seismic data, which are telemetered in near-real-time to the UUSS operations center and archived at the public data center of the Incorporated Research Institutions for Seismology (IRIS, see [www.iris.edu](http://www.iris.edu)). Station density is greater along the Wasatch Front, an area of high seismic hazard. In addition to the seismic network, UUSS operates nine infrasound arrays throughout the state in collaboration with Southern Methodist University and Los Alamos National Laboratory (Hale et al., 2010).

Seismic signals from the Bingham Canyon landslide were recorded by UUSS at distances ranging from ~6 to over 400 km, while infrasound signals were recorded at seven arrays at distances from 13 to 400 km. Inspection of the seismic data importantly revealed that the landslide consisted of two distinct rock avalanche events separated by ~1.5 h. Raw seismograms for the two rock avalanches appear similar and are dominated by persistent, long-period (>10 s) energy; however, isolation of the long-period signals reveals significant differences (Fig. 3). For example, low-passed data from the first rock avalanche show a high-amplitude peak near the end of the coda, a feature that the



second event lacks; meanwhile, the timing of the two maxima differs by tens of seconds.

Inspection of the infrasound data confirms that there were two distinct rock avalanche events. Figure 3 shows beams formed by steering the arrays at two stations, NOQ and WMUT, toward the mine. For the first rock avalanche, there is a coherent signal on both arrays, arriving at times consistent with the slide as the source. However, at NOQ (13 km from the mine) the energy consists primarily of a sharp impulse, while at WMUT (57 km from the mine) the energy is >30 s in duration with both a long onset and coda. Differences in the waveforms likely result from different atmospheric travel paths. For the second rock avalanche, array processing shows no coherent signal at NOQ coming from the mine, while the coherent signal at WMUT is short in duration and only slightly visible above background noise. Infrasound data from the second event are more difficult to discern because of increased background noise, possibly due to local winds (there was a rainstorm the night of the landslide).

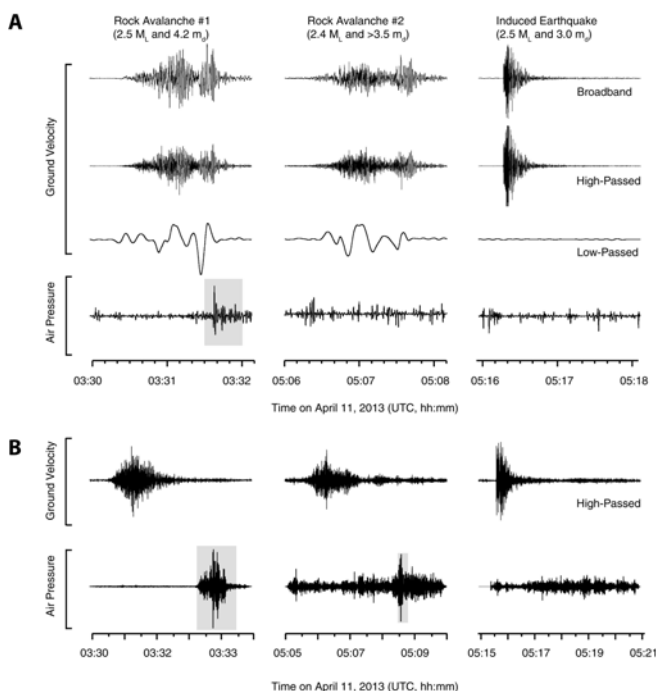


Figure 3. (A) Seismic and acoustic waveforms recorded at NOQ (13 km from slide), the closest broadband seismic station. Seismic traces are vertical component-velocity in different frequency bands (broadband, high-passed at 1 Hz, low-passed at 0.1 Hz); acoustic traces are infrasonic beams steered toward the mine in a pass band of 0.5–5.0 Hz. Gray box indicates time period with coherent signal originating from the mine. Amplitude scales are consistent for each pass band (i.e., they are consistent across each row). (B) Same as in (A) for seismic and acoustic waveforms recorded at station WMUT (57 km from the slide). Seismic traces were recorded by a short-period vertical-component seismometer.

We can use the seismic observations to generate first-order estimates of the relative volumes of the two rock avalanches. Comparing signal durations, peak amplitudes of the seismogram envelopes, and area underneath each envelope (as in Dammeier et al., 2011), we find that the two slides were roughly equal in volume; this would correspondingly split and move the data point presented in Figure 2. We note, however, that photographs suggest that the second rock avalanche likely contained a greater proportion of waste-rock deposited on the slope during previous mining and so may have had a lower bulk density than the first failure. Photographs also show that the first rock avalanche filled the entire pit floor, while the second ap-

parently stopped short of the southern wall, suggesting the first slide may have been slightly larger.

The ultra-emergent nature of seismic signals from the rock avalanches made standard earthquake detection algorithms employed by UUSS ineffective. Such power detectors rely on short-term versus long-term averages and are tuned to alarm on impulsive P waves. However, the two rock avalanches were automatically detected and located using an algorithm based on the continuous back propagation of globally recorded long-period surface waves (Ekström, 2006), which has previously been successful in detecting large landslides (Ekström and Stark, 2013). The detection amplitudes correspond to surface-wave magnitudes ( $M_s$ ) of 5.1 and 4.9 for the first and second events, respectively (G. Ekström, personal commun., 2013).

With no clear P-wave arrivals, UUSS determined the location for the two rock avalanches at 40.536°N 112.142°W using satellite images. Origin times of 03:30:22 and 05:05:22 on 11 April 2013 (UTC) were estimated by subtracting 1 s from the arrival time of the initial seismic energy at nearby stations (CFS, 6 km away; MID, 8 km away). Given the unknown phase of the first arrivals, we are unable to calculate a more precise time. Using the estimated location, local (ML) and duration ( $m_d$ , also known as  $M_c$  or coda magnitude) magnitudes for the first rock avalanche were calculated to be 2.5 and 4.2, respectively. For the second rock avalanche, the magnitudes were 2.4 and 3.5, respectively. Raw waveforms for each slide show two successive packets of energy with approximately equal peak amplitudes (Fig. 3A). For the first rock avalanche, the trailing packet is dominated by low-frequency energy, while for the second event it is rich in high-frequency energy. This secondary pulse of high-frequency energy for the second slide results in waveforms that differ from the typical coda decay seen in earthquakes or in the first rock avalanche (Fig. 3B) and makes comparison of duration magnitudes between the two events difficult. The  $m_d$  3.5 for the second rock avalanche should thus be considered a lower bound.

The two UUSS magnitudes scales are designed to overlap seamlessly. For the 6,664 earthquakes that occurred in the Utah region during 2000–2011 and were large enough for ML to be estimated, the mean  $ML-m_d$  difference is only -0.12 with a standard deviation of 0.30. Therefore, the large  $ML-m_d$  values observed for the two rock avalanches (-1.7 and <-1.1) are indicative of non-earthquake seismic sources, and are consistent with enhanced ratios of long-period to short-period energy relative to earthquakes (cf. Fig. 3). This, in turn, is consistent with previous seismic observations of landslides showing large  $M_s-m_b$  differences compared to earthquakes (Weichert et al., 1994).

There were no obvious seismic or acoustic signals preceding the first rock avalanche. However, immediately following the second slide, an  $ML$  2.5 ( $m_d$  3.0) earthquake, plus three smaller quakes, occurred at shallow depths (<2 km) beneath the mine. All four of these events were automatically detected and located using normal UUSS procedures. The events have short impulsive waveforms (Fig. 3) that are characteristic of tectonic earthquakes and unlike the rock avalanche waveforms. Cross-correlation analyses using the  $ML$  2.5 event and the three smaller quakes as templates (Kubacki et al., 2013) suggest the existence of twelve additional earthquakes, with magnitudes ranging from  $ML$  -0.8 to 0.5. Six occurred between the two rock avalanches, five occurred in the two days following the second rock avalanche, and one occurred ten days later on April 20 (Fig. 4). There were no earthquakes detected in the ten days preceding the first slide. The coincidence between the timing of these tectonic events and the landslide suggests the tectonic events are triggered aftershocks of the rock avalanches. Other shallow, non-earthquake seismic sources, such as mine collapses (Pechmann et al.,



2008) and nuclear explosions (Ford and Walter, 2010), have been known to generate aftershock sequences. The causative nature of aftershock triggering at the Bingham Canyon mine can be confirmed by detailed analysis of previous seismicity in the area, which will be pursued in a future study.

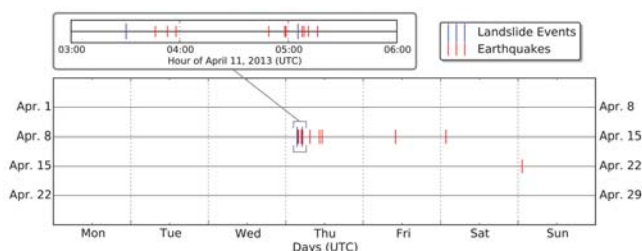


Figure 4. Time period of cross-correlation template analysis. Earthquake activity began shortly after the first rock avalanche and ceased 10 days later.

#### FUTURE RESEARCH DIRECTIONS

Initial observations of the Bingham Canyon landslide presented here indicate a complex sequence of events consisting of two large rock avalanches and sixteen smaller, possibly triggered, earthquakes. Clearly, much work remains in order to understand the details of this sequence. Important research questions include

- How is the geometry of the rock avalanches reflected in the geophysical data?
- Do the seismic and infrasound signals have a common source?
- Are differences in the seismic and infrasound signals of the two rock avalanches related to different physical properties of the mass flows?
- Can the long-period seismic radiation be well fit by an equivalent-force model dominated by a single force, or is a more complex source model required?
- How are the 16 small seismic events ( $\sim -0.8$ – $3.0$   $m_d$ ) that occurred in the mine area in the ten days following the landslide related to the two rock avalanches?

#### ACKNOWLEDGMENTS

This work was partially supported by the State of Utah under a line-item appropriation to the University of Utah Seismograph Stations (UUS) and by the U.S. Geological Survey, Department of the Interior, under USGS award number G10AC00085. We thank Kennecott Utah Copper for providing the photograph used in Figure 1. Figures 1A, 3, and 4 were drawn using the Generic Mapping Tools (<http://gmt.soest.hawaii.edu>; Wessel and Smith, 1998).

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## Lyme Regis landslip stabilisation: Coastal conservation

**Major ground stabilisation that will blend in with the environment sounds too good to be true, doesn't it? But that is exactly what a scheme in the Dorset town of Lyme Regis is aiming to deliver.**



*Coastal protection: The haul road provided access and protected the World Heritage rock ledges*

Most clients would expect to be able to see the results of investing £19.5M but the main benefit of work to stabilise a landslide in Lyme Regis will be its ability to blend in with its environment. According to Balfour Beatty Construction Services project manager Chris Hill, the aim at the end of the scheme is for the only difference to be that the landslide risk to have been removed.

**The wet weather in 2012 caused eight shallow landslips during the early stages of the work – the changing geomorphology meant the design has had to be changed and checked throughout**

The scheme is the fourth stage of ground stabilisation to be completed in Lyme in the bid to halt the historic landslide which the town is built on and will conclude work that first started in the early 1990s.

This current phase focuses on the eastern side of the town - East Cliff and Church Cliff - and replaces a 70-year-old seawall that is in a poor state of repair and where the landslide is at risk of moving over the top of it.

"The work will protect around 240 houses and a 900m section of the Charmouth Road - the main access route into Lyme - which would be at risk over the next 50 years," says Hill.

The client is West Dorset District Council, but only £600,000 of the cost is being met by the local council. Dorset County Council is also contributing £4.27M but the remaining £14.6M of the funding is coming from Defra and was secured when the Environment Agency approved the scheme in March 2012.

Work on site started in 2012 and the main civils work is expected to be completed this spring.

According to Hill, Dean & Dyball, a subsidiary of Balfour Beatty, won the design and construct scheme on the basis of quality rather than cost. "This project is an environmental challenge as much as an engineering one - the site forms part of the World Heritage Jurassic Coast and there is a Site of Special Scientific Interest too," says Hill. "We won the contract through our demonstration of our understanding of the challenges and local knowledge."

Hill, as well as a number of the team, have all worked on

previous phases of the stabilisation work at Lyme so the project has the benefit of local knowledge. Nonetheless, this phase is more rural than previous ones and the landslide is more active, so the challenges are different.



"The wet weather in 2012 caused eight shallow landslips during the early stages of the work," says Hill. "The changing geomorphology meant that the design has had to be changed and checked throughout the work."

Much of the early work on site focused on protecting the ecology. "The vegetation was mapped and during the clearance measures were taken to move the native species, such as reptiles and dormice, from west to east."

More ground investigation was carried out during these early stages by CC Ground Investigation. "We already had lots of information but we needed some more detail in some areas," says Hill.

**The construction is all within the tidal zone so the work has to be timed around the tides**

During this stage Datum was called in to install new monitoring instrumentation with inclinometers and piezometers to supplement the existing instrumentation. "All the new equipment is automated and uses solar power," says Hill.

"The system reports to a web-based system in real time with trigger levels set for raising alerts with the project team."

"The system helped prove that the movements that have occurred since we moved onto site are a natural part of the landslide movement and not as a result of the work itself."

The first main construction work was installation of a 4m deep drain below the car park on Charmouth Road and Spittles Lane, where the site office is located, to create a ground water cut off.

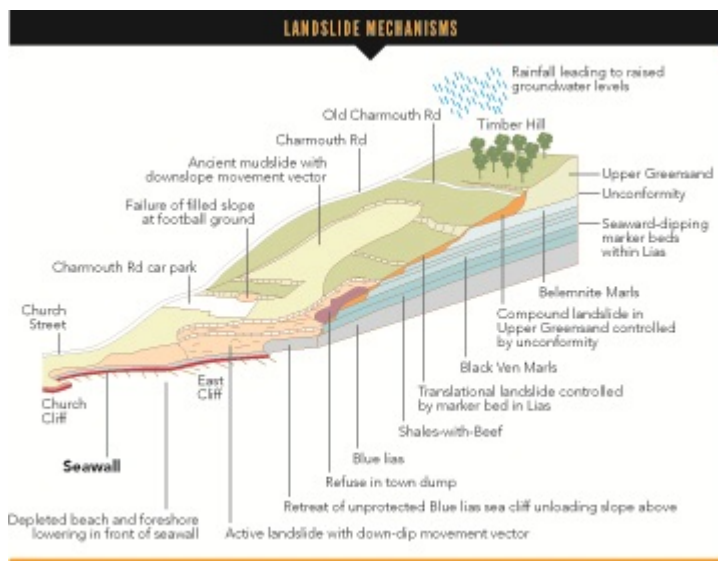
Another early stage in the project saw a haul road installed in front of the existing seawall to provide access and to protect the rock ledges that form a distinctive part of the World Heritage site. The haul road material will be used later in the project as backfill material.

"The sea wall is a conventional design but has a 2.3m deep toe rather than using a rock apron to protect it as that would obscure the rock ledges," explains Hill. "The deep toe also caters for future foreshore lowering."

The sea wall has been cast insitu in 8m bays using bespoke formwork with a four-day turnaround for each section. "The construction is all within the tidal zone so the work has to be timed around the tides," says Hill.

"The formation level of the wall is not fixed but is based on excavating to one of three specific geological horizons and the cage design allows for the varying depth," he explains.

"The geology at the foreshore is weak mudstones interbedded with harder ones, hence the erosion problems. We have a geologist on site who is looking for beds of the Third Quick, Top Tape or Second Tape, which vary in thickness from 100 to 300mm."



Fossils have been found on the site during the work. "We have had a specialist on site to check for fossils throughout the work," says Hill. "The large ammonites we have found will be used as features in the sea wall, but we have also found shark teeth and an Ichthyosaurus vertebrae."

The wall will be finished with 370t of rock armour formed with stone from the Mendips at the eastern end of the sea wall.

While the sea wall will protect the toe of the landslide, the upper slopes of the system are being stabilised using 2,500 soil nails installed by Can Geotechnical using rope access techniques and A-frame rigs, as well as excavator-mounted drill rigs. "The nailing area protects Church and East Cliff and then wrap around the back scar," says Hill.

### The stabilisation is designed to be zero maintenance

The aim is to create a transition zone between the stabilised area and the still active landslides to the east, as well as to protect the natural habitats of the wildlife that used to thrive in the area.

"The nails we are using are a hybrid system - open holes with flush and a hollow bar - to allow the nail to be measured before grouting."

The nails are up to 19m long but some are as short as 8m and are being installed at 25° to the horizontal. "The rock dips at 2.5° towards the sea and the angle of the nails is the best one to ensure we can drill through the harder beds," says Hill.

The nails are being installed on a grid pattern of 2m horizontal and 1m vertical in staggered rows, although the locations in some areas have been changed. "We found a lot of old rubble-filled drains in the cliffs and we have relocated nails to prevent the work grouting up these drains," says Hill.

Once installed, the nails will be covered with Geobrug Ultra Coat Tecco mesh, which has a high corrosion resistance with a 60 to 120-year design life. The nail heads will be recessed using a bespoke design developed by Can and URS to ensure the stabilised slopes look natural at the end of the work.

"The stabilisation is designed to be zero maintenance," says Hill.

So far 1,500 nails have been installed and mesh installation started in January. Hill expects that element of the work to be completed by the end of March.

The work also includes installation of gravity drains that follow the natural dip of the rock and are designed to drain the slip plane.

### Micro topography

The nailing work has concentrated on maintaining the micro topography of the slopes. "It would have been easier to regrade all the slopes but the aim is for the end result to look much as it did before, but without the risk of landslips," says Hill. "The need to maintain the look of the area is partly the reason why the soil nailing doesn't extend across the whole site but focuses on protecting the at risk properties and road."

The soil nailing work will be further supported by two banks of small diameter dowel piles above East Cliff. The 8m to 12m long, 300mm diameter piles will be filled with grout and reinforced with a steel tube and are designed to protect the new sea wall and prevent shallow landslips from progressing inland.

The final part of the stabilisation involves piling around the top edge of the work area to create a cut off through the slip surface. Work on installing the 86 900mm diameter bored piles started in January and extends a piled wall installed by Balfour Beatty as emergency works in 2004. The new single row of heavily reinforced 27m deep piles will extend the wall westwards and will be topped by a capping beam and tied back using multi-strand ground anchors.

Once all the stabilisation work is complete, the whole area will be reseeded with native species using seeds from more than 700 plant species that were collected from the site before the start of the work. If Hill's team is successful in delivering their aim, the only evidence of the work will be the new sea wall.

"It will take two years for the vegetation to re-establish itself but the use of seeds gathered from the site will mean that the final appearance will be natural," says Hill.

### Community communication

Demonstrating an understanding of the ecological, as well as environmental, challenges may have been a key part of Dean & Dyball's securing of the Lyme Regis contract, but communication with the local community also played a key role.

"West Dorset District Council established the Coastal Forum in the early stages of the stabilisation work in the 1990s and it has continued to meet every quarter since then," says Balfour Beatty's Chris Hill.



"The open public format has been a good way for us to get feedback on our work. We have been fortunate to have almost 100% support for what we're doing."

Despite the support, Hill's team have made efforts to ensure that the work does not impact on the town - especially during the busy summer months. "Deliveries are carefully planned around the tides and we hold trucks at our site office to prevent congestion in the actual town centre," explains Hill.

The site has also hosted a number of visits for local schools, business group and also one for members of the ICE.

(Claire Smith / Ground Engineering, February 2014, <http://www.nce.co.uk/8658793.article>)

## A twist in the tale: Victoria Street, London

**Inventive site logistics and complex temporary works are vital for deep basement work in central London.**



Drop down: The 13 storey office and 14 storey residential buildings will have basements up to five storeys deep

As property prices in central London soar, and space is limited, developers are looking at innovative ways to create space below the capital's surface, by building ever deeper and more space efficient basements, to match the great heights of our developing skyline. Constructing these complex sub-structures below London's congested streets requires a great deal of skill and engineering expertise, but that is only half the challenge.

Space is not a luxury afforded to London developers, and building within seemingly impossible spaces involves thinking outside the box.

Land Securities is developing one such scheme on Victoria Street, the main thoroughfare between Victoria Station and Parliament Square. Once complete, the aptly named Zig-Zag commercial and retail building will stand 13 storeys tall and incorporate a four storey basement, which will house service rooms and one level of retail. Its residential neighbour, Kings Gate, is due to be 14 storeys high and incorporate a five storey basement, providing very valuable car parking space for residents.

The two buildings sit together within a 160m long and 75m wide site, surrounded by busy roads, and close to Westminster City Hall and London Underground's District & Circle Line.

It imposes great discipline on organising the site during the day to find space for materials to go exactly where they are needed next

"Our basements are within 1m of the Tube for much of their length and at one point touch the tunnel structures" says Ian Ronchetti, project director for Lend Lease, which is managing the £170M design and construct project. "On top of that, the site is split into three, with a major UK Power Networks (UKPN) substation being constructed to power the whole of Victoria bisecting the site at basement level," he says.

"Both the basements for the Zig-Zag building and the three storey deep UKPN substation were constructed using conventional strutted excavation. A different strategy was devised for Kings Gate. To optimise the construction programme on the residential works, we proposed to construct the five story basement utilising top-down construction. This will allow the superstructure to rise while we are simultaneously excavating the basement, shaving several months off the programme, therefore allowing the client to

take possession of the high-end apartments at the earliest time."

Top-down construction means added complications for PJ Carey, the Wembley based civil engineering contractor which has been assigned the £30M basement and super-structure contract.

The first challenge was finding space to manage its work.

"There is virtually nowhere for laydown storage" says PJ Carey contract manager Bradley Barham. Two small entries to the site are available, from a side street and one running underneath the city hall where there is limited headroom. From here, a small route can be found alongside the structure, but the other entrance opens only onto an area sitting over the District & Circle Line.

"The access route runs on top of a Victorian brick arch, which required approval from London Underground (LU) to allow wagons to pass above with normal axle loadings" says Barham.

### Invaluable space

Further along, the arch gives way to a brick sided box tunnel, and here the contractor requested space to store materials. After discussion with LU engineers, a system was developed and agreed for laying steel beams across the tunnel roof to take loads to the side walls. The space found is "invaluable" says Barham.

Even that is insufficient for major deliveries. The team therefore needed to negotiate the possession of one lane of Victoria Street between 6.30pm and 9:30pm, to allow articulated wagons to be unloaded by the three tower cranes on site.

"The tight delivery window imposes great discipline on the management team to organise the site during the day, and to find space for materials to go exactly where they are needed next," says Barham.

Our basement has to come within 1m of the Tube and at one point touches it

Positioning and erecting the tower cranes within the excavation was a challenge in itself. Two sit at the edge of the site on two plunge piles and the capping beam of the secant pile wall, while the third stands on four plunge column legs.

The secant wall was carried out by Expanded Group and was an early part of the work while demolition was being carried out on the old 1960s concrete and glass offices, which used to run like a cliff wall along the full length of the frontage.

Working as a subcontractor to Lend Lease, Expanded began work in October 2012 and overlapped with the demolition which continued until Christmas 2013.

Since then, 556 secant piles have been driven, up to 20m into the London clay, which sits beneath approximately 5m of gravel and 2m of centuries old fill, which combined make up London's surface.

Expanded's works also included just fewer than 50 bored piles for the apartments, each between 1.5m and 2m in diameter and 40m long, and fitted with a steel plunge column.

Drilling the piles meant breaking through the old basement slab and removing the support for the existing basement wall. In total 7,000m<sup>3</sup> of old concrete basement slab and foundations were removed.

Support was provided for the existing wall by a system of complicated steel king posts strutted obliquely from the existing slab.

This system was devised jointly by Carey and Swantons Consultants, with cantilevered projections to hold the wall vertically and horizontally.

"The old slab is above the level of the first new basement slab," says Barham, "and so we would have needed to underpin the old wall without this support."

The first excavation task was for the central UKPN substation section which was separated with sheet piles, and then excavated with heavy tubular steel strutting. This is also used for the main office basement.

### **Bespoke strutting**

Carey likes to use bespoke strutting, rather than a proprietary system, to provide more flexibility to fit struts and allow for rising internal slabs and structures, once the base slab is installed.

The UKPN substation space splits the site awkwardly, and requires heavy steel shielding to contain the magnetism from the two large transformers. Laminated layers of connected plates have been used and penetrate the final concrete structures.

Current work is in the main office section, where the raft slab is in place, after excavation from a plunge column-mounted steel platform. In reality, the top down construction of the basement is the most complex element of works, mainly due to the space limitations of the car park design.

An unusual "spiral slab" has been used in the design. This slab provides parking space on each level and also acts as the ramp between the car park levels.

"To allow excavation at this point, a system of K-bracing struts is needed to hold the ramp in place until the slab is cast right around to the next connection point," says Barham.

Together with a rearranged grid for columns inside the car park, the Lend Lease design created a significant number of additional spaces.

But to achieve the spiralling design, some very large transfer beams were required at the top of the spiral for the ground floor slab to sit on.

"Excavation is in progress using a special Hitachi 23t excavator mounted with a telescopic box boom. This allows a 21.5m reach for the clamshell bucket, which pulls out the clay and is much faster than a conventional methodology," says Barham.

Work is now proceeding apace and the basement and the reinforced concrete frame will be completed in autumn 2014. The the project is due to open in spring 2015.

(Adrian Greeman / NCE, 10 February, 2014,  
<http://m.nce.co.uk/8658754.article>)

# ΠΑΡΟΥΣΙΑΣΗ ΕΡΕΥΝΗΤΙΚΟΥ ΠΡΟΓΡΑΜΜΑΤΟΣ

**SHARE**

Seismic Hazard Harmonization in Europe

SHARE is a Collaborative Project in the Cooperation programme of the Seventh Framework Program of the European Commission. SHARE's main objective is to provide a community-based seismic hazard model for the Euro-Mediterranean region with update mechanisms.

SHARE successfully delivered a European wide probabilistic seismic hazard assessment across multiple disciplines spanning from geology to seismology and earthquake engineering. The project built a framework for integration across national borders, compiled relevant earthquake and fault data, and developed a sustainable, high-impact community-based hazard model assembled by seeking extensive expert elicitation and participation through multiple community feedback procedures. In total, the project produced a time-independent European Seismic Hazard Model (ESHMs) spanning spectral ordinates from PGA to 10 seconds and exceedance probabilities ranging from 10<sup>-1</sup> to 10<sup>-4</sup> yearly probability.

The model complexity varies with the location as a consequence of tectonic regionalization. The hazard values are referenced to a rock velocity of  $v_{s30}=800\text{m/s}$  and were computed using the OpenQuake hazard engine developed within the Global Earthquake Model (GEM) initiative, intensively interacting with the SHARE modelling team as the first large applicant of the code. Hazard curves, uniform hazard spectra (UHS) and disaggregation results are computed for more than 120,000 sites on-land within Europe and Turkey, spaced at a distance of 10km. The project has now established new standards in Probabilistic Seismic Hazard Assessment (PSHA) practice by a close cooperation of leading European geologists, seismologists and engineers.

## European Seismic Hazard Map 2013

The EU-FP7 project SHARE has delivered a first complete harmonized seismic hazard model, characterizing the hazard and its uncertainty. This model now serves as reference model for Europe and Turkey. It provides input for risk assessment and earthquake resistant design for applications ranging from engineering single and multi-story homes to critical infrastructures. Through the coordination at the European Union level, these results help to harmonize the next generation of national seismic hazard assessments and the implementation of the European seismic building code (EC8). SHARE results do, however, not replace the currently existing national design regulations and seismic provisions which should be obeyed for today's design and construction of buildings.

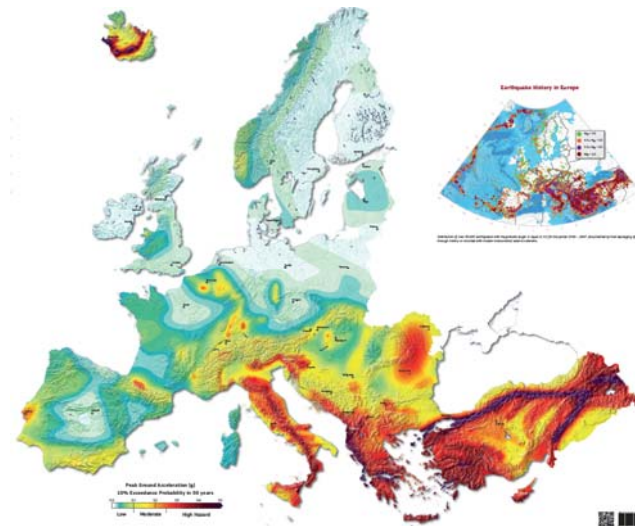
## Poster Availability

As icon of the project, we have created a poster (A0 format) with the major achievements and a representative harmonized seismic hazard map (see Figure below).

The poster highlights

1. The European Seismic Hazard Map with the colors indicating the Peak Ground Acceleration (PGA) expected to be reached or exceeded with a 10% probability in 50 years, or to return on average every 475 years;
2. The Earthquake History of Europe from 1000-2007 A.D.;
3. Active Faults and Subduction zones in the Euro-Mediterranean region superimposed on the estimated plate deformation.

Posters are now available and can be ordered from the [project website](#). Costs cover our shipping expenses. Additional digital copies are also available for download.





# ΠΑΡΟΥΣΙΑΣΗ ΠΕΡΙΛΗΨΕΩΝ ΕΛΛΗΝΙΚΩΝ ΔΙΔΑΚΤΟΡΙΚΩΝ ΔΙΑΤΡΙΒΩΝ ΓΕΩΜΗΧΑΝΙΚΗΣ

## Διερεύνηση της μη-γραμμικής συμπεριφοράς των εδαφικών υλικών με προσομοίωση του ερπυσμού

Αλέξανδρος Ν. Καλός

### ΠΕΡΙΛΗΨΗ

Στην παρούσα διδακτορική διατριβή καταστρώνεται ένα νέο χρονικά εξαρτημένο καταστατικό πλαίσιο συμπεριφοράς. Το καινούριο αυτό πλαίσιο θεμελιώνεται πάνω στις ελαστοπλαστικές αρχές των δομημένων γεωυλικών ενώ παράλληλα ενσωματώνει ένα επιπλέον σύνολο δομητικών (π.χ. βελτιωμένων νόμους αποδόμησης της δομής και κινηματικής κράτυνσης της κλίσης  $c$  και της μετάθεσης  $d$  μέσω της συσσώρευσης πλαστικών παραμορφώσεων) και χρονικά εξαρτημένων χαρακτηριστικών (π.χ. την απομείωση της περιβάλλουσας αστοχίας μέσω της συσσώρευσης ερπυστικών παραμορφώσεων).

Η επιτακτική ανάγκη για την διατύπωση ενός νέου καταστατικού πλαισίου συμπεριφοράς απορρέει από την ανεπάρκεια των υφιστάμενων μεθοδολογιών να προσομοιώσουν τον μηχανισμό της προοδευτικής αστοχίας σε πρηνή, στηριζόμενα αποκλειστικά και μόνο σε ελαστοπλαστικά χαρακτηριστικά. Η ουσιώδης ατέλεια των ελαστοπλαστικών προσομοιωμάτων απορρέει από την αδυναμία ελέγχου του μεγέθους των πλαστικών παραμορφώσεων. Συνεπώς, δεν δύνανται να συσσωρευτούν σημαντικές ανελαστικές παραμορφώσεις που να οδηγούν στην ενεργοποίηση του μηχανισμού της προοδευτικής αστοχίας. Η ενσωμάτωση ωστόσο των ερπυστικών χαρακτηριστικών επιτρέπει την δυνατότητα ελέγχου των ανελαστικών παραμορφώσεων μέσω της ερπυστικής συνιστώσας. Αποδεικνύεται ότι είναι ο συνδυασμός των δομητικών και των ερπυστικών χαρακτηριστικών που οδηγεί στην αστοχία.

Το εξιδανικευμένο προσομοίωμα θεμελιώνεται επί της κλασικής θεωρίας πλαστικότητας των εδαφικών υλικών ολοκληρωμένη εντός του πλαισίου της θεωρίας υπερφόρτισης (Perzyna, 1962 & 1966). Τόσο ο μηχανισμός γήρανσης (που οδηγεί σε αύξηση της αντοχής λόγω της αύξησης της τάσης προστερεοποίησης) όσο και ο μηχανισμός ερπυστικής αστοχίας (που απορρέει από την απομείωση της περιβάλλουσας αντοχής) ενσωματώνονται επιτυχώς εντός των καταστατικών εξισώσεων. Το εξιδανικευμένο προσομοίωμα αξιολογείται σε αριθμητικές αναλύσεις υλικού σημείου και σε επίπεδο πεπερασμένων στοιχείων καθώς και έναντι εργαστηριακών δοκιμών. Αποδεικνύεται ότι το χρονικά εξαρτημένο καταστατικό πλαίσιο συμπεριφοράς προσομοιώνει επιτυχώς τους μηχανισμούς γήρανσης και ερπυστικής αστοχίας (μέσω της συσσώρευσης ανελαστικών παραμορφώσεων).

Το προτεινόμενο εξιδανικευμένο προσομοίωμα χρησιμοποιήθηκε επιτυχώς στην πρόβλεψη του μηχανισμού προοδευτικής αστοχίας σε ένα πλήρως κορεσμένο πρηνές.

Η διατριβή εκπονήθηκε στον Τομέα Γεωτεχνικής του Εθνικού Μετσοβίου Πολυτεχνείου υπό την επίβλεψη του κ. Καββαδά, Αναπληρωτή Καθηγητή Ε.Μ.Π. και εξετάστηκε την Δευτέρα 28 Απριλίου 2014.



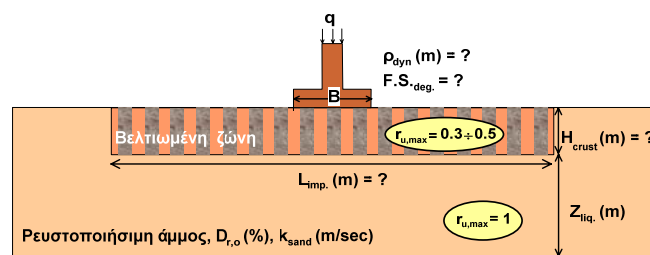
## Αντισεισμικός σχεδιασμός με κριτήρια επιτελεσματικότητας και μέθοδοι ενίσχυσης επιφανειακών θεμελιώσεων σε ρευστοποιήσιμα εδάφη

Βασιλική Ε. Δημητριάδη

### ΠΕΡΙΛΗΨΗ

#### Εισαγωγή

Η εκδήλωση ρευστοποίησης λόγω σεισμού προκαλεί σημαντική απομείωση της διατμητικής αντοχής του εδάφους, με αποτέλεσμα τη συσσώρευση δυναμικών καθιζήσεων σε επιφανειακές θεμελιώσεις τεχνικών έργων, καθώς και την προσωρινή απομείωση της μετασεισμικής φέρουσας ικανότητας των θεμελιώσεων αυτών έως και την αστοχία. Πειραματικά αποτελέσματα και επιτόπου παρατηρήσεις, υποδεικνύουν ότι η παρουσία μιας μη-ρευστοποιήσιμης κρούστας εδάφους, ικανών διαστάσεων και αντοχής, μπορεί να μετριάσει τις ανωτέρω επιπτώσεις της ρευστοποίησης, εξασφαλίζοντας την ικανοποιητική σεισμική συμπεριφορά των επιφανειακών θεμελιώσεων. Ωστόσο, η απουσία μιας ολοκληρωμένης μεθοδολογίας σχεδιασμού επιφανειακών θεμελιώσεων σε ρευστοποιήσιμα εδάφη, υπό τις ανωτέρω συνθήκες, δεν επιτρέπει την αξιοποίηση των ανωτέρω συμπερασμάτων στην πράξη και οδηγεί στην υπερ-συντηρητική και δαπανηρή λύση της βαθιάς θεμελίωσης με πασσάλους και καθολικής βελτίωσης της ρευστοποίησης στρώσης. Για την κάλυψη του ανωτέρω κενού, η παρούσα εργασία πραγματεύεται την ανάπτυξη μιας ολοκληρωμένης μεθοδολογίας σχεδιασμού επιφανειακών θεμελιώσεων μεγάλου μήκους (πεδιλοδοκών) σε ρευστοποιήσιμα εδάφη, με περιορισμένο βάθος και πλάτος βελτίωσης, όπως παρουσιάζεται στο **Σχήμα 1**, λαμβάνοντας υπόψη κριτήρια επιτελεσματικότητας (καθιζήσεων και φέρουσας ικανότητας).



**Σχήμα 1:** Σχηματική απεικόνιση του εξεταζόμενου προβλήματος και ορισμός βασικών παραμέτρων.

#### Επιμέρους εργασίες

**Βιβλιογραφική Αναδρομή.-** Η τεχνητά διαμορφωμένη επιφανειακή κρούστα θα πρέπει να πληροί συγκεκριμένες προδιαγραφές κατασκευής και υλικών, αλλά και να είναι σχεδιασμένη σύμφωνα με καλά τεκμηριωμένες μεθοδολογίες. Έτσι, στα πρώτα κεφάλαια της διατριβής, συνοψίζονται οι αντίστοιχες προδιαγραφές, και περιγράφονται οι διαθέσιμες μεθοδολογίες βελτίωσης ρευστοποιήσιμων εδαφών και υπολογισμού των μηχανικών χαρακτηριστικών του βελτιωμένου εδάφους. Στη συνέχεια, αναλύονται τα βασικά στάδια σχεδιασμού γεφυρών και κτιρίων με κριτήρια επιτελεσματικότητας (performance based design), τα οποία περιλαμβάνουν τον

προσδιορισμό: (i) των σεισμικών δράσεων σχεδιασμού, (ii) των επιθυμητών επιπέδων λειτουργικότητας και την ποσοτικοποίηση αυτών σε (iii) επιτρεπόμενα όρια παραμορφώσεων ανάλογα με τον τύπο και το υλικό κατασκευής.

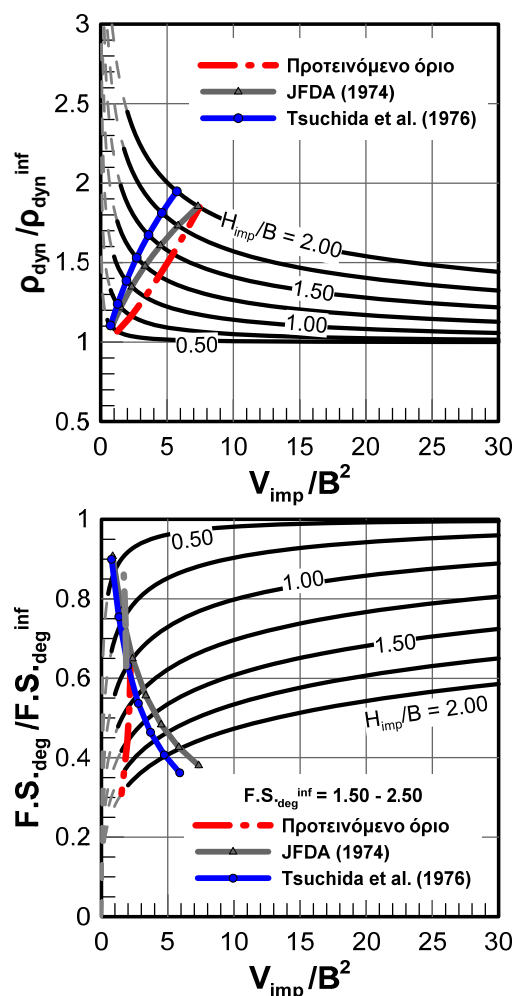
**Μεθοδολογία Σχεδιασμού Χαλικοπασσάλων – Στραγγιστηρίων.** Η αποστραγγιστική δράση των χαλικοπασσάλων, δηλαδή η μερική αποτόνωση των υδατικών υπερπίεσεων που προκαλεί η σεισμική δόνηση, αποτιμάται με τη βοήθεια κατάλληλων διαγραμμάτων σχεδιασμού [π.χ. Seed & Booker (1977), Bouckovalas et al. (2009)]. Πειραματικές μετρήσεις, αποδεικνύουν την ανάγκη επανεξέτασης των παραδοχών των ανωτέρω αναλυτικών λύσεων, και συγκεκριμένα την επανεξέταση της βασικής σχέσης που περιγράφει την ανάπτυξη υδατικών υπερπίεσεων  $r_u - N/N_L$ . Έτσι, σε συνδυασμό με την πλέον πρόσφατη μεθοδολογία των Bouckovalas et al. (2009) προτείνονται νέα διαγράμματα σχεδιασμού. Στη συνέχεια, η αξιοπιστία των νέων διαγραμμάτων σχεδιασμού ελέγχεται μέσω της αριθμητικής προσομοίωσης της απόστραγγιστικής δράσης των χαλικοπασσάλων και τη διεξαγωγή σοφιστευμένων 3-Δ δυναμικών μη-γραμμικών αναλύσεων.

**Βαθμονόμηση αριθμητικών αναλύσεων.** Το πρώτο βήμα για την ανάπτυξη της αναλυτικής μεθοδολογίας, περιλαμβάνει τη θεώρηση του «Ισοδύναμου Ομοιόμορφου Βελτιωμένου Εδάφους», στο πλαίσιο της αριθμητικής προσομοίωσης της επιφανειακής κρούστας βελτιωμένου εδάφους. Η εν λόγω κρούστα, θεωρείται ομοιόμορφη, με κατάλληλα βελτιωμένες εδαφικές ιδιότητες (σχετική πυκνότητα και διαπερατότητα). Μετά τον καθορισμό των βασικών παραδοχών της αριθμητικής προσομοίωσης μιας επιφανειακής θεμελίωσης επί της ανωτέρω βελτιωμένης κρούστας, μέσω αναλύσεων ευαισθησίας, εντοπίζονται και περιγράφονται οι μηχανισμοί οι οποίοι διέπουν τόσο τη συσσώρευση των δυναμικών καθιζήσεων όσο και το μηχανισμό αστοχίας της θεμελίωσης. Εν συνεχεία, η αριθμητική μεθοδολογία συγκρίνεται και βαθμονομείται σε όρους σεισμικών καθιζήσεων και λόγου επιταχύνσεων θεμελίου/βάσης, έναντι των καλά τεκμηριωμένων πειραμάτων σε φυγοκεντρίστη των Liu & Dobry (1997).

**Παραμετρική Διερεύνηση.** Με αποδεδειγμένη την αξιοπιστία της αριθμητικής μεθοδολογίας, πραγματοποιείται μια σειρά αριθμητικών αναλύσεων ελεύθερου πεδίου, μέσω των οποίων προσδιορίζεται ο απαιτούμενος συντελεστής αντικατάστασης  $a_{sr}$  ανάλογα με τον επιτρεπόμενο μέγιστο λόγο υπερπίεσεων  $r_{u,max}$  εντός της βελτιωμένης εδαφικής κρούστας, το επιθυμητό πάχος αυτής  $H_{imp}$ , και την αρχική σχετική πυκνότητα του φυσικού εδάφους  $D_{ro}$  (%). Ακολουθεί η πραγματοποίηση της πρώτης ομάδας των 84 αριθμητικών αναλύσεων, οι οποίες εξετάζουν την επίδραση: (i) εδαφικών ιδιοτήτων (ii) σεισμολογικών παραμέτρων καθώς και (iii) των παραμέτρων του θεμελίου στη σεισμική απόκριση μιας θεμελίωσης εδραζόμενης σε μια βελτιωμένη κρούστα «άπειρης» έκτασης. Η επίδραση του πλάτους της βελτίωσης ( $L_{imp}$ ) μελετάται ανεξάρτητα, μέσω 96 επιπλέον παραμετρικών αναλύσεων, στις οποίες το πλάτος της βελτίωσης μειώνεται σταδιακά από τις συνθήκες βάσης βελτίωσης, έως περίπου το πλάτος του ίδιου του θεμελίου.

**Διατύπωση Αναλυτικών Σχέσεων.** Για βελτίωση άπειρης οριζόντιας έκτασης, η προκύπτουσα σχέση υπολογισμού της απομειωμένης φέρουσας ικανότητας  $q_{ultdeg}^{inf}$  μετά το πέρας της δόνησης, βασίζεται στην αναλυτική σχέση των Meyerhoff & Hanna (1978), η οποία τροποποιείται κατάλληλα, ώστε να περιγράφει τις ιδιαίτερες συνθήκες του προβλήματος. Οι σεισμικές καθιζήσεις  $\rho_{dyn}^{inf}$ , υπολογίζονται με βάση μια αναλυτική έκφραση, η οποία είναι συμβατή με τη θεώρηση δυναμικής αστοχίας τύπου “ολισθαίνοντας στερεού” (Newmark), συναρτήσει των χαρακτηριστικών της δόνησης (μέγιστη επιτάχυνση στη βάση του εδαφικού στρώματος  $a_{max}(g)$ , αριθμός σημαντικών κύκλων της φόρτισης  $N_o$ , δεσπόζουσα περίοδος της διέγερσης  $T_{exc}(sec)$ , της ελαστικής περιόδου της εδαφικής στήλης  $T_{soil}(sec)$  και του απομειωμένου συντελεστή φέρουσας ικανότητας της θεμελίωσης  $F.S._{deg}^{inf}$ .

Η στατιστική επεξεργασία της δεύτερης ομάδας των αριθμητικών αναλύσεων, για πεπερασμένη πλευρική έκταση βελτίωσης οδηγεί στη διατύπωση των αντίστοιχων αναλυτικών σχέσεων υπολογισμού των σεισμικών καθιζήσεων και της απομειωμένης φέρουσας ικανότητας. Προς διευκόλυνση ωστόσο της χρήσης της αναλυτικής μεθοδολογίας, προτείνονται τα διαγράμματα σχεδιασμού του **Σχήματος 2**, τα οποία επιτρέπουν την εκτίμηση του λόγου των σεισμικών καθιζήσεων και του απομειωμένου συντελεστή ασφαλείας για πεπερασμένου πλάτους και βάθους βελτίωσης, ως συνάρτηση των αντίστοιχων προβλέψεων για άπειρη βελτίωση, καθώς και το λόγο  $V_{imp}/B^2$ , όπου  $B$  το πλάτος του θεμελίου και  $V_{imp}$  ο όγκος της βελτιωμένης ζώνης, οριζόμενος ως το γινόμενο του πλάτους επί το βάθος της βελτιωμένης ζώνης. Τα προτεινόμενα όρια “βέλτιστης οικονομο-τεχνικά βελτίωσης” από τις αριθμητικές αναλύσεις, διαπιστώνεται ότι συμφωνούν ικανοποιητικά με τα όρια που προτείνονται από την Ιαπωνική Υπηρεσία Πυροπροστασίας (JFDA, 1974) και τους Tsuchida et al. (1976) για τη βελτίωση ρευστοποιήσιμων εδαφών πριν την κατασκευή επιφανειακών θεμελιώσεων.



**Σχήμα 2:** Λόγος δυναμικών καθιζήσεων περιορισμένης ( $\rho_{dyn}$ ) προς άπειρη βελτίωση ( $\rho_{dyn}^{inf}$ ) και απομειωμένου συντελεστή ασφαλείας για περιορισμένη ( $F.S._{deg}$ ) προς άπειρη βελτίωση ( $F.S._{deg}^{inf}$ ) συναρτήσει του λόγου  $V_{imp}/B^2$  για διαφορετικές τιμές του λόγου  $H_{imp}/B$  για αρχικές τιμές απομειωμένου συντελεστή ασφαλείας  $F.S._{deg}^{inf} = 1.50 - 2.50$ .

#### Συμπεράσματα

Τα προτεινόμενα όρια “βέλτιστης οικονομο-τεχνικά βελτίωσης”, από τις αριθμητικές αναλύσεις, συμφωνούν ικανοποιητικά με τα όρια που προτείνονται από τους διαθέσιμους κανονισμούς. Η μεγιστοποίηση των ωφελιών από την παρουσία της επιφανειακής βελτιωμένης κρούστας επιτυγχάνονται για σχετικά εκτενές εύρος βελτίωσης, το οποίο φτάνει έως και 20 φορές το πλάτος του θεμελίου, επιφέροντας και την

εκτόξευση του αντίστοιχου κόστους κατασκευής. Συνεπώς, η προτεινόμενη μεθοδολογία σχεδιασμού είναι τεχνικά και οικονομικά βιώσιμη για τιμές πλάτους ( $L_{imp}$ ) και βάθους ( $H_{imp}$ ) βελτίωσης 2 – 3.5 και 0.50 έως 2.00 φορές το πλάτος του θεμελίου B αντίστοιχα.

Η διατριβή εκπονήθηκε στον Τομέα Γεωτεχνικής του Εθνικού Μετσοβίου Πολυτεχνείου υπό την επίβλεψη του κ. Μπουκοβάλα, Καθηγητή Ε.Μ.Π. και εξετάσθηκε την Τρίτη 29 Απριλίου 2014.

# ΔΙΑΚΡΙΣΕΙΣ ΕΛΛΗΝΩΝ ΓΕΩΜΗΧΑΝΙΚΩΝ

## Βράβευση

Μαριάννας Λώλη και Ιωάννη Αναστασόπουλου

Στο 8<sup>ο</sup> Διεθνές Συνέδριο «Physical Modelling in Geotechnics 2014» (ICPMG2014), που διεξήχθη από τις 14 έως τις 17 Ιανουαρίου 2014 στο Perth της Αυστραλίας (στο University of Western Australia), τα μέλη του Εργαστηρίου Εδαφομηχανικής του ΕΜΠ, Μαριάννα Λώλη και Ιωάννης Αναστασόπουλος τιμήθηκαν με το ICPMG2014 **Best Paper Award**.





# ΝΕΑ ΑΠΟ ΤΙΣ ΕΛΛΗΝΙΚΕΣ ΚΑΙ ΔΙΕΘΝΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΝΩΣΕΙΣ



FEDERATION OF INTERNATIONAL  
GEO-ENGINEERING SOCIETIES

<http://fedigs.geosindex.com>

## FedIGS Elects Professor Jean-Louis Briaud New President



Professor Jean-Louis Briaud has been elected FedIGS President. In his new role, the former ISSMGE president will help bring together experts from four international geo-technical societies.

Professor Jean-Louis Briaud was very recently elected President of the Federation of International Geo-engineering Societies (FedIGS) for the 2014-2018 term. FedIGS re-groups the following international societies:

- ISSMGE: International Society for Soil Mechanics and Geotechnical Engineering
- ISRM: International Society for Rock Mechanics
- IAEG: International Association for Engineering Geology and the Environment
- IGS: International Geosynthetics Society

Dr. Briaud is a former president of ISSMGE (2009-2013). As President of FedIGS, Briaud plans to foster cooperation and strengthen the links between the four societies while remaining conscious of each society's freedom. Briaud also wishes to strengthen the group by inviting other geo-engineering societies to join FedIGS.

Briaud says that this prestigious and humbling position will give him a chance to broaden his horizons and learn more about rock mechanics, engineering geology, geosynthetics, and other aspects of the rich geoworld. Briaud also plans to work on enhancing the image of the geo-profession which he sees as a long-term but very important goal.

Dr. Briaud is Professor and Holder of the Buchanan Chair in the Zachry Department of Civil Engineering at Texas A&M University. He received his Bachelor's degree in France in 1972 and his Ph.D. degree from the University of Ottawa in Canada in 1978. His expertise is in foundation engineering and more generally geotechnical engineering. He has served as President of the Association of Geotechnical Engineering Professors in the USA, President of the Geo-Institute of the American Society of Civil Engineers, and President of the International Society for Soil Mechanics



International Society for Rock Mechanics



newsletter

Infomail, 28th February 2014

Dear Member

The ISRM Digital Library, with the papers from ISRM meetings and congresses, is hosted by OnePetro and run by the Society of Petroleum Engineers.

ISRM individual members are allowed to download up to 100 papers from ISRM meetings per year, while corporate members are allowed 250 yearly downloads.

OnePetro has recently upgraded their site and unfortunately the way you used to log in was deactivated. The usernames and passwords you used for OnePetro no longer work.

The ISRM Secretariat and OnePetro have been working in a new way to give access to ISRM members, which is now implemented:

- Every ISRM member was given a token, which is a unique numerical string.
- You can obtain your token by logging in at the ISRM website and then clicking on "My Account", on the left of the screen. The token is near the bottom of the screen.
- Then go to the OnePetro site, click on "Register to purchase instant access" and follow the instructions. The OnePetro site username and password are different from those you use at the ISRM site.
- After logging in with your new OnePetro credentials, go to "My Account", then to "Society Memberships" and click on "Add membership details".
- Under "Add ISRM membership" click on "Redeem your ISRM access token here".
- Insert your token in order to activate it and follow the instructions on the page. Shortly after you will be able to download the ISRM papers for free.

Please feel free to send our Webmaster an email if you run into any trouble.

Best regards

Luís Lamas  
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Lisboa, PORTUGAL  
Tel: (+351) 218443419; Fax: (+351) 218443021;  
Website: [www.isrm.net](http://www.isrm.net); E-mail: [secretariat@isrm.net](mailto:secretariat@isrm.net)

and Geotechnical Engineering. Among other awards, he has received the ASCE Ralph Peck Award, the CGS Geoffrey Meyerhof Foundation Engineering Award, the ASTM Hogen-togler Award, the ASCE Huber Research Prize, and the ASCE Martin Kapp Award. Over the last 30 years, Dr. Bri-aud has conducted about 8.5 million dollars of research mostly on foundations and retaining walls. He has super-vised 49 PhD students and 90 Master students. He has been a consultant on many projects in several countries. He is the author of the 1992 book on "the pressuremeter" and the 2013 book on "geotechnical engineering: unsaturated and saturated soils". He has published about 300 articles and reports in geotechnical engineering and has lectured worldwide.

# ΠΡΟΣΕΧΕΙΣ ΕΚΔΗΛΩΣΕΙΣ ΓΕΩΤΕΧΝΙΚΟΥ ΕΝΔΙΑΦΕΡΟΝΤΟΣ ΣΤΗΝ ΕΛΛΑΔΑ

- Rehabilitation and repair
- Safety and security in tunnels and tunnelling
- Contractual and financial issues
- Education and training
- Case histories
- Underground space use
- Tunnels and monuments



**30 September - 3 October 2014, Athens, Greece**  
[www.eetc2014athens.org](http://www.eetc2014athens.org)

It is our pleasure to inform you that the Greek Tunnelling Society is organizing the 2<sup>nd</sup> Eastern European Tunnelling Conference in Athens on September 28 – October 1 2014 (EETC2014, Athens).

The Eastern European Tunnelling Conference is a biennial regional traveling conference. It aims to promote the sharing of knowledge, experience, skills, ideas and achievements in the design, financing and contracting, construction, operation and maintenance of tunnels and other underground facilities among the countries of Eastern Europe, on an organized basis and with agreed aims. EETC2014 aims mainly to bring together colleagues from Eastern Europe but people from the rest of the world are also welcome.

The theme of EETC2014 Athens is:

**"Tunnelling in a Challenging Environment"**  
*Making tunnelling business in difficult times*

The construction of underground projects is becoming increasingly demanding as new challenges are emerging in every aspect and sector of this multidisciplinary and multi-various business. Further to the usual geological, geotechnical, structural and operational challenges, we are now facing a difficult business and financial environment, which requires the deployment of even more intelligent and effective tools and solutions.

I really do hope that the EETC2014 Athens will contribute and further facilitate the growth of the tunnelling business and will be a forum for scientific and professional collaboration.

## TOPICS:

- Innovative methods for Analysis and Design
- Tunnelling in difficult ground conditions
- Conventional urban or shallow tunnelling
- Mechanized tunnelling
- Hydraulic tunnels
- Underground complexes
- Caverns for Hydropower or Storage
- Pipe jacking and microtunnelling
- Innovations in tunnelling construction technology
- Tunnels and shafts for mining

**7<sup>ο</sup> ΠΑΝΕΛΛΗΝΙΟ ΣΥΝΕΔΡΙΟ  
ΓΕΩΤΕΧΝΙΚΗΣ ΜΗΧΑΝΙΚΗΣ**

**5 – 7 Νοεμβρίου 2014, ΑΙΓΛΗ Ζαππειού, Αθήνα**  
<http://www.7hcge2014.gr>

Η Ελληνική Επιστημονική Εταιρεία Εδαφομηχανικής και Γεωτεχνικής Μηχανικής, στο πλαίσιο των δραστηριοτήτων της, διοργανώνει το 7ο Πανελλήνιο Συνέδριο Γεωτεχνικής Μηχανικής υπό την αιγίδα του Δήμου Αθηναίων και του Τεχνικού Επιμελητηρίου Ελλάδας. Στόχος του Συνεδρίου είναι να καταγράψει τις προόδους της γεωτεχνικής μηχανικής στην Ελλάδα του 21ου αιώνα όπως αντικατοπτρίζονται στα σημαντικά γεωτεχνικά αλλά και άλλα έργα (σιδηροδρομικά, οδοποιία, λιμενικά, υδραυλικά, κτιριακά, περιβαλλοντικά) με σημαντικό γεωτεχνικό αντικείμενο, που έχουν μελετηθεί και κατασκευαστεί ή κατασκευάζονται, καθώς και στα αποτελέσματα της ερευνητικής δραστηριότητας των ελληνικών πολυτεχνείων και πολυτεχνικών σχολών. Επιδίωξη είναι οι εργασίες του Συνεδρίου να αναδείξουν πρωτότυπα στοιχεία συμβολής της γεωτεχνικής μηχανικής αλλά και να προβάλουν θεωρητικές και πειραματικές έρευνες σε εδαφικά, βραχώδη και ημιβραχώδη υλικά που βρήκαν ή μπορούν να βρουν εφαρμογή στην πράξη."

## Θεματικές Ενότητες

1. Συμπεριφορά Εδαφών: Έρευνες Υπαίθρου και Εργαστηρίου
2. Συμπεριφορά Εδαφών: Προσομοιώματα
3. Επιφανειακές και Βαθείες Θεμελιώσεις
4. Αλληλεπίδραση Εδάφους - Κατασκευής
5. Πρανή - Κατολισθήσεις
6. Βαθείες Εκσκαφές - Αντιστηρίξεις
7. Σήραγγες
8. Βελτιώσεις Εδαφών
9. Φράγματα, Άοπλα Επιχώματα
10. Οπλισμένα Επιχώματα
11. Εφαρμογή Ευρωκωδίκων
12. Εφαρμογές Γεωσυνθετικών Υλικών
13. Εδαφοδυναμική / Τεχνική Σεισμολογία
14. Βραχομηχανική
15. Περιβαλλοντική Γεωτεχνική
16. Ενεργειακή Γεωτεχνική (energy geotechnics)
17. Πολιτιστική Κληρονομιά και Γεωτεχνική Μηχανική
18. Διδασκαλία και Μάθηση Γεωτεχνικής Μηχανικής

# ΠΡΟΣΕΧΕΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΚΔΗΛΩΣΕΙΣ

Για τις παλαιότερες καταχωρήσεις περισσότερες πληροφορίες μπορούν να αναζητηθούν στα προηγούμενα τεύχη του «περιοδικού» και στις παρατιθέμενες ιστοσελίδες.

82nd Annual Meeting of ICOLD: Dams in Global Environmental Challenges, Bali, Indonesia ~ 1-6 June 2014,  
<http://www.icold2014bali.org>

World Landslide Forum 3, 2 – 6 June 2014, Beijing, China,  
<http://wlf3.professional.com>



On behalf of the organizing committee, we are delighted to invite you to participate in 2014 ISRM Conference on Soft Rocks (ISSR2014) to be held in Beijing, China, on June 6-7, 2014. This Symposium is a common endeavor of ISRM Commission on Soft Rocks, Chinese Society for Rock Mechanics and Engineering (CSRME) and State Key Laboratory of GeoMechanics and Deep Underground Engineering, who are doing their best to offer a pleasant and interesting event.

We have prepared an appealing program with a good number of keynote lectures by some of the world's leading experts on soft rock mechanics. Some experts will also present lectures representing the latest advancement and frontier achievements in soft rock mechanics.

You will also have the privilege to visit our city and country. Lively and dynamic, Beijing is an old and modern city, very famous for its long history, ancient culture and modern architecture.

It is a special honor for us to host for ISSR2014 in China and we strongly hope that an exciting program and the charms of Beijing will combine to make this a successful and memorable event.

We look forward to meeting you in Beijing in June 2014.

## Theme & Topics

- Concept and classification of soft rocks;
- Physical and mechanical characterization of soft rocks;
- Stability analysis, monitoring and control technology of soft-rock slope;

- Deformation mechanism and control technology of soft-rock tunnels;
- Design measures of soft-rock engineering

Excellent papers will be selected to be published in the Journal of Rock Mechanics and Geotechnical Engineering or in the International Journal of Mining Science and Technology.

## Contact

Secretariat

Dr. Na Zhang, Email: [ISSR2014@gmail.com](mailto:ISSR2014@gmail.com)

Chinese Society for Rock Mechanics and Engineering (NG China of ISRM)

Ms. Wen-li Xu, Email: [csrme@163.com](mailto:csrme@163.com)



4th Annual Underground Infrastructure & Deep Foundations Qatar, 08 - 11 June, 2014, Doha, Qatar, [enquiry@iqpc.ae](mailto:enquiry@iqpc.ae)



This ISRM Specialised Conference is organised by the Peruvian Society of Geoengineering (the ISRM National Group of Peru) and integrates the activities of the ISRM Commission on Design Methodology. It will take place in Lima, Peru, 9-11 June 2014.

Classification systems and characterization of rock masses, its application in design, either by empirical methods or numerical methods are currently employed throughout the world mining industry. The main objective of the event is to bring together users and designers to present, discuss and share their experiences with these design techniques. In addition to the lectures that we will present, you will find short courses, field trips, posters and a technical exhibition. We invite you to be part of this event.

## Information and Registration

Phone: (511) 437 7854

[info@geoingenieria.org.pe](mailto:info@geoingenieria.org.pe)

[inscripciones@geoingenieria.org.pe](mailto:inscripciones@geoingenieria.org.pe)

[Geoingenieria2014@gmail.com](mailto:Geoingenieria2014@gmail.com)



6<sup>ème</sup> Journées Africaines de la Géotechnique  
9 - 13 June 2014, Ouagadougou, Burkina Faso



Organizer: CTGA  
 Contact person: Dr Etienne Marcelin Kana  
 Address: 5, Rue Monseigneur Graffin, B.P 20369, Yaounde,  
 Cameroon  
 Phone: +23799500510  
 E-mail: [emk2cm@yahoo.fr](mailto:emk2cm@yahoo.fr)



The 12<sup>th</sup> International Workshop on Micropiles (IWM),  
 Kraków, Poland, June 11-14, 2014,  
<http://www.iwm2014.org>

GeoHazards 6, June 15 – 18, 2014, Kingston, Canada,  
<http://www.geohazards6.ca>

ISSMGE Technical Committee 207 INTERNATIONAL CON-  
 FERENCE ON GEOTECHNICS Soil-Structure Interaction  
 Underground Structures and Retaining Walls, Saint Peters-  
 burg, 16-18 June 2014, [www.tc207ssi.org](http://www.tc207ssi.org)

8th European Conference "Numerical Methods in Geotechni-  
 cal Engineering" NUMGE14, Delft, The Netherlands, 17-20  
 June 2014, [www.numge2014.org](http://www.numge2014.org)



### **The 6th International Conference on Unsaturated Soils UNSAT 2014 02 - 04 July 2014, Sydney, Australia**

Contact person: Adrian Russell, [a.russell@unsw.edu.au](mailto:a.russell@unsw.edu.au)



2<sup>nd</sup> International Conference on Vulnerability and Risk Ana-  
 lysis and Management & 6<sup>th</sup> International Symposium on  
 Uncertainty Modelling and Analysis - Mini-Symposium  
 Simulation-Based Structural Vulnerability Assessment and  
 Risk Quantification in Earthquake Engineering, 13-16 July  
 2014, Liverpool, United Kingdom,  
<http://www.icvram2014.org>

GeoHubei 2014 International Conference Sustainable Civil  
 Infrastructures: Innovative Technologies and Materials, July  
 20-22, 2014, Hubei, China  
<http://geohubei2014.geoconf.org>

ICITG 2014 Second International Conference on Informa-  
 tion Technology in Geo-Engineering, 21-22 July 2014, Dur-  
 ham, UK, [www.icitg.dur.ac.uk](http://www.icitg.dur.ac.uk)

Second European Conference on Earthquake Engineering  
 and Seismology, 24-29 August 2014, Istanbul, Turkey  
[www.2eceedistanbul.org](http://www.2eceedistanbul.org)

TC204 ISSMGE International Symposium on "Geotechnical  
 Aspects of Underground Construction in Soft Ground" - IS-  
 Seoul 2014, 25-27 August 2014, Seoul, Korea,  
[csyoo@skku.edu](mailto:csyoo@skku.edu)



### **International Conference on Advances in Civil Engineering for Sustainable Development 27-29 August 2014, Nakhon Ratchasima, Thailand <http://acesd.sut.ac.th/index.php?acesd=9c847ec878ac085f8c0c829a241d5a35>**

The School of Civil Engineering, Suranaree University of  
 Technology, being determined and dedicated to excel in  
 instructions, research, academic service, and transfer of  
 technology, will host a conference on Progress in Civil Engi-  
 neering for Sustainable Development (ACESD 2014), 27-29  
 August 2014, at Suranaree University of Technology, to  
 commemorate its two decades in 2014, in cooperation with  
 Research Center for Excellence in Civil Engineering, Asso-  
 ciation of Engineering Institutes of Thailand under Royal  
 Patronage and Geosynthetics Society, with the following pur-  
 poses:

1. To provide a forum for disseminations of modern knowl-  
 edge of and information on civil engineering and struc-  
 ture engineering by scholars, researchers, and engineers  
 from around the world.
2. To act as a venue for presentations of research results in  
 the applications of agricultural and industrial waste mate-  
 rials within the domain of civil engineering, to reduce en-  
 vironmental and pollution problems.
3. To provide an arena for presentations of research results  
 in the development of smart engineering materials and  
 smart basic structures within the sphere of civil engineer-  
 ing.
4. To provide a forum for presentations of research results  
 in soil improvement techniques and applications of syn-  
 thetic materials in the work of civil engineering.
5. To act as a place for exchanges of new knowledge and  
 experience in research among academics, researchers,  
 and engineers in and outside Thailand for sustainable de-  
 velopment of new bodies of knowledge in civil engineer-  
 ing and creations of cooperation networks among aca-  
 demics, researchers, and engineers from different coun-  
 tries.

#### **Topics**

- Pavements and Railways  
 Pavement materials and structures  
 Innovative pavement analysis and design  
 Pavement management systems  
 Long-term pavement performance prediction  
 Non-destructive testing of asphalt pavement  
 Modeling of asphaltic materials and pavements  
 Pavement response analysis under static and moving  
 wheel loads  
 Pavement Recycling  
 Geotechnics of road and railtrack structures  
 Railway geotechnics  
 Railway structures: Bridges, tunnels and transition  
 zones  
 Track design, construction and maintenance  
 Track monitoring  
 Trackbeds: Sleepers and ties  
 Other related topics
- Ground improvements and Ground controls

Compaction of soil and granular materials  
 Deep soil improvement  
 Soil stabilization with lime and cement  
 Geosynthetics Applications  
 Foundations  
 Geomechanics  
 Seepage and porous mechanics  
 Rock mechanics and rock engineering  
 Other related topics

- Smart materials and Smart structures

Composite Material and Structures  
 Concrete Technology  
 New Construction Materials  
 Geopolymer composite materials  
 Lightweight materials  
 Innovations in Structural Design  
 Structural and Solid Mechanics  
 Structural Dynamics  
 Sustainable Buildings  
 Tall Buildings  
 Other related topics

- Water Supply

Water Resources and Desalination  
 Water pumping and Distribution  
 Priority issues related to water resources: natural water quality trends  
 Conventional and advanced treatment processes for drinking water  
 Water Treatment plants operation  
 Reliability improvement of water supply systems;  
 Sludge from water treatment plant and application (treatment and management)  
 Energy efficiency at water and wastewater plants  
 Energy-saving and energy efficiency in water and wastewater treatment systems  
 Energy-saving and energy efficiency in water and wastewater distribution networks  
 Water leakage management  
 Global warming for water issues  
 GIS (application & Technology)  
 Other related topics

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International Symposium on Geomechanics from Micro to Macro (TC105), 01 - 03 September 2014, Cambridge, United Kingdom, <http://is-cambridge.eng.cam.ac.uk>

International Conference on Industrial and Hazardous Waste Management "CRETE 2014", September 2<sup>nd</sup> - 5<sup>th</sup>, 2014, Chania, Crete, Greece, <http://www.hwm-conferences.tuc.gr>

Geosynthetics mining solutions 2014, September 8 - 11, 2014, Vancouver, Canada, <http://www.geosyntheticssolutions.com>

JUBILEE CONFERENCE 50th Anniversary of Danube-European Conferences on Geotechnical Engineering Geotechnics of Roads and Railways, 9 - 11 September 2014, Vienna, Austria, [www.decqe2014.at](http://www.decqe2014.at)

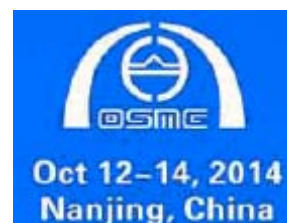
IAEG XII CONGRESS Torino 2014 Engineering Geology for Society and Territory, IAEG 50th Anniversary, September 15-19, 2014, Torino, Italy, [www.iaeg2014.com](http://www.iaeg2014.com)

10th International Conference on Geosynthetics - 10ICG, Berlin, Germany, 21 - 25 September 2014 [www.10icg-berlin.com](http://www.10icg-berlin.com)

14th International Conference of the International Association for Computer Methods and Advances in Geomechanics (14IACMAG), September 22 - 25, 2014, Kyoto, Japan, [www.14iacmag.org](http://www.14iacmag.org)

14th World Conference of the Associated Research Centers for the Urban Underground Space (ACUUS 2014), September 24-26, 2014, Seoul, Korea <http://acuus2014.com>

EETC 2014 ATHENS 2nd Eastern European Tunnelling Conference, 28 September - 1 October 2014, Athens, Greece, [www.eetc2014athens.org](http://www.eetc2014athens.org)



## 5th International Forum on Opto-electronic Sensor-based Monitoring in Geo-engineering (5th OSMG-2014)

Oct 12-14, 2014, Nanjing, China  
<http://www.osmg2014.com>

The 5th International Forum on Opto-electronic Sensor-based Monitoring in Geo-engineering (5th OSMG-2014) will be held in Nanjing, China, on Oct 12-14, 2014. This forum was sponsored by Nanjing University, and organized by Center for Engineering Monitoring with Opto-Electronic Sensing (CEMOES) of Nanjing University, and Nanjing University High-Tech Institute at Suzhou. The co-organizers of this forum include NSFC, China National Group of IAEG, ISHMII, ISEG, The Hong Kong Polytechnic University, fibris Terre GmbH, Suzhou Nanzee Sensing Co. Ltd, and 41<sup>st</sup> Institute of China Electronics Technology Group Corporation.

The theme of this forum is "Monitoring and Early Warning of Geological Disasters". There will be about 250 delegates in this forum. About 20 outstanding experts will be invited to give the plenary presentations. The 4th Short Course on Distributed Fiber Optic Sensing Technologies will be held during the forum. Some well-known production suppliers

will come to exhibit their products. Several Best Paper Awards and Outstanding Contribution Awards will be conferred at the forum.

With the rapid development in the construction of civil infrastructures and the frequent occurrence of severe weather conditions and earthquakes in China, there have been more and more geological disasters, including landslides, debris flows, land collapse, ground subsidence and fissures, which have caused tremendous losses in the lives and properties. To prevent and mitigate various potential disasters, the improvement of the level of engineering monitoring technology is of great importance. In recent years, the opto-electronic sensor-based monitoring technologies, such as the distributed fiber optic sensing technologies, such as Brillouin optical frequency/time domain technologies (BOTDR/A, BOFDR/A, OTDA, COTDR), Raman optical time domain technologies (ROTOR), fiber Bragg grating technologies (FBG), optical interferometry technologies, optical fiber fluorescence technologies, electric Frequency / Time Domain technologies (TDR, FDA), and Micro-Electro-Mechanism System (MEMS) technologies, have played an increasingly important role in monitoring and early warning of geological disasters. Due to their apparent advantages, the development and application of these technologies have become a research focus all over the world.

As the fifth forum following the 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, and 4<sup>th</sup> International Forums on Opto-electronic Sensor-based Monitoring in Geoengineering held by Nanjing University, China, in 2005, 2007, 2010, and 2012, respectively, this forum will focus on the subject of "Monitoring and Early Warning of Geological Disasters", on which related topics will be discussed and communicated. During the forum, some well-known foreign and domestic scholars and experts will be invited to give keynote lectures on up-to-date research findings, hotspots and difficult subjects in the geo-engineering monitoring field. An information release and communication platform for new technologies and products of relevant suppliers will be provided, as well.

#### MAIN TOPICS

- Recent development of opto-electronic sensor-based monitoring technologies
- Innovative demodulation technologies for opto-electronic sensing network
- Data acquisition and wireless transmission technologies of opto-electronic sensing network
- Temperature compensation and abnormality recognition of opto-electronic sensing network
- Distributed monitoring technologies of multi-field information engineering geology
- Solutions of field installation and data transmission of fiber optic sensors
- Monitoring and early warning systems of geological disasters based on opto-electronic sensing network
- Development of special opto-electronic sensors for monitoring geological disasters
- Integration of opto-electronic sensing network in monitoring geological disasters
- Monitoring technologies of geo-materials with large deformation
- Monitoring and early warning of rockfalls, landslides, debris flows, ground subsidence and fissures
- Monitoring of ground deformation induced by the construction of urban rail transits, hydraulic structures, ultra-high-voltage transmission structures, etc.
- Distributed monitoring in protection of historic buildings
- Distributed monitoring in mining and deep underground engineering

#### CONTACT

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- Fax: +86-25-83597888
- Website: [www.osmq2014.com](http://www.osmq2014.com)



International Congress Tunnels and Underground Space risks & opportunities, 13-15 October 2014, Lyon, France, [www.congres.aftes.asso.fr/en/content/invitation](http://www.congres.aftes.asso.fr/en/content/invitation)

ARMS 8 - 8th ISRM Rock Mechanics Symposium, 14-16 October 2014, Sapporo, Japan  
[www.rocknet-japan.org/ARMS8/index.htm](http://www.rocknet-japan.org/ARMS8/index.htm)

9<sup>th</sup> International Conference on Structural Analysis of Historic Constructions, 14 - 17 October 2014, Mexico City, Mexico, [www.linkedin.com/groups/SAHC-2014-Mexico-City-3930057.S.213150607](http://www.linkedin.com/groups/SAHC-2014-Mexico-City-3930057.S.213150607)



#### **6th International Conference on Protection of Structures Against Hazards 16-17 October 2014, Tianjin, China <http://cipremier.com/page.php?764>**

Catastrophic consequences could occur as a result of inadequate provisions or lack of understanding of the performance of structures/components subjected to hazardous man-made loads or loads caused by nature. And, it is only through the experience and ingenuity of Man that the number of fatal and catastrophic incidences is reduced. Extensive research, testing and advanced computational modeling have been used to better understand the effects of loading on the performance of structures and components. Nature, too, has its way of creating an optimum solution to support loading. The aim of this conference is to provide a platform of like-minded individuals from a diversity of background to exchange ideas and to interact productively to deliver better understanding of the complex world we live in.

This conference addresses topics related to the protection of buildings/components and occupants to natural and man-made hazards. The conference considers issues that will promote better understanding of the performance of structures and components. Innovative solutions are needed to address many matters occurring daily, and scientists, researchers and engineers are in the best position to address them.

Special topics, such as protection of occupants in buildings from the hazards of chemical or biological contamination and the hardening of structures to protect occupants from the effects of explosions, vibration of structures, earthquake effects, fire safety for structures, ground subsidence, etc. are specially welcomed.

## Conference Theme

The engineering and technological aspects and issues that will make buildings and structures safer against:

- Terrorists attacks
- Impact and shock loads
- Fire
- Chemical and biological hazards
- Structural collapse (architectural, structural and construction)
- Corrosion and natural degradation
- Natural hazards (landslides, earthquakes, tsunami, hurricanes, etc)
- Vibrations
- Ground subsidence
- Blast Effects on Structures
- Geotechnical Hazards
- Hazards in Dams
- Floods and bushfires (or wildfires)
- Climate Change

Related issues are also invited, such as:

- Mitigation (preventive measures)
- Rescue, safety and evacuation techniques
- Risk and reliability
- Disaster Prevention

Other important themes within the scope of the Conference may be considered for inclusion and discussion.

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E-mail: ci-p@cipremier.com website: [www.cipremier.com](http://www.cipremier.com)



2<sup>nd</sup> International Conference Innovations on Bridges and Soil - Bridge Interaction IBSBI 2014, Athens, 16 - 18 October, 2014, <http://ibsbi2014.ntua.gr>

1st International Conference on Volcanic Landscapes (VOLAND 2014), 16 - 18 October 2014, Santorini Island, Greece, [voland@heliotopos.net](mailto:voland@heliotopos.net)

1st International Conference on Discrete Fracture Network Engineering, October 19 - 22, 2014, Vancouver, British Columbia, Canada, [www.dfne2014.ca](http://www.dfne2014.ca)



**12<sup>th</sup> International Conference  
Underground Infrastructure of Urban Areas  
22-23th October 2014, Wroclaw, Poland  
<http://www.uiua2011.pwr.wroc.pl>**

The aim of conference is to create a forum in order to develop an exchange of experiences and provoke a discussion on the topics related to building of tunnels and underground infrastructure in the cities. The issues such as geotechnical tests and town planning could also be brought up in this forum. The discussion on various problems related to underground infrastructure such as tunnels (traffic and rail-

way tunnels, and underground), water and sewage ducts, garages, and subways is anticipated. It is hoped that the possibilities of using an underground space associated with town planning and modernization of cities will be analysed as well. An important impulse for the conference is starting the studies on the design of Wroclaw underground.

The organizers wish to involve a wide body of people from different sectors. Scientists, investors, designers, contractors, and students have different point of view and thus possibly varying opinions. It is hoped that the analysis and the comparison of these different views will allow drawing a fruitful conclusions. The subject matter of conference is very crucial and up-to-date due to a current need for adjusting underground infrastructures to nowadays standards and requirements. The impact of these structures on the environment and the principles of sustainable development have to be considered nowadays.

## CONTACT

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with a postscript:

"Underground Infrastructure of Urban Areas 2014"

e-mail: [uiua2014@pwr.wroc.pl](mailto:uiua2014@pwr.wroc.pl)



**AusRock 2014  
3rd Australasian Ground Control in Mining  
Conference - an ISRM Specialized Conference  
5 - 6 November 2014, Sydney, Australia**

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**3rd ISRM International Young Scholars'  
Symposium on Rock mechanics -  
an ISRM Specialized Conference  
8 - 11 November 2014, Xi'an, China**

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7th International Congress on Environmental Geotechnics,  
10-14 November 2014, Melbourne, Australia,  
[www.7iceq2014.com](http://www.7iceq2014.com)

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**GEOMATE 2014**  
**Fourth International Conference on**  
**Geotechnique, Construction Materials +**  
**Environment**  
**19 - 21 Nov. 2014, Brisbane, Australia**  
<http://www.geomate.org>

The Fourth International Conference on Geotechnique, Construction Materials and Environment, GEOMATE 2014, will be held in Brisbane from 19 to 21 November 2014, in conjunction with the University of Southern Queensland, Australia, GHD, Australia, GEOMATE International Society, AOI-Engineering, Useful Plant Spread Society, HOJUN and Glorious International. It aims to provide a great opportunity to share common interests in geo-engineering, construction materials, environmental issues, water resources, and earthquake and tsunami disasters.

The conference will be dedicated to those affected by the tragic Tohoku-Kanto earthquake which occurred on Friday 11 March 2011, at 14:46 Japan Standard Time, in which the north east of Japan was severely damaged.

The three previous events were held in Tsu City, Mie, Japan, Kuala Lumpur, Malaysia, and Nagoya, Japan, with more than 150 participants at each event. The organisers encourage and welcome your enthusiastic participation and look forward to receiving contributions demonstrating in-depth multi-disciplinary technology towards new research and development.

#### Themes

Conference themes will consider papers in the following topics:

- Advances in Composite Materials
- Computational Mechanics
- Foundation and Retaining Walls
- Slope Stability
- Soil Dynamics
- Soil-Structure Interaction
- Pavement Technology
- Tunnels and Anchors
- Site Investigation and Rehabilitation
- Ecology and Land Development
- Water Resources Planning
- Environmental Management
- Earthquake and Tsunami Issues
- Safety and Reliability
- Geo-Hazard Mitigation
- Case History and Practical Experience
- Others

#### Secretariat

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**20-21 November 2014, Kathmandu, Nepal**  
<http://www.ngetechns.org/ngs/index.php/geohazards-2014>

As one of the most important branches of civil engineering, geotechnical engineering probably has the longest history of development. Some of the first geotechnical construction activities were traced back in the form of irrigation and flood control dykes, dams, and canals in ancient Egypt that were built as early as 2000 years ago. However, up until the 18th century, all knowledge was limited in the form of an art than a science relying largely on past experience. It was only in the 19th century the geotechnical engineering started to receive greater theoretical basis. In about past 200 years, this discipline has developed extensively, but basic theories and principles still remain the same and what have changed in recent times are experimental techniques, advances in numerical modeling, and design standards. Today, the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) brings together all geotechnical engineering professionals and researchers into a single forum and streamlines any further development of this discipline.

However, the gap in practice of geotechnical engineering principles between developed and developing nations is immensely wide. Many developing nations do not adequately consider geotechnical engineering design in infrastructure development and building construction. Nepal, for example, despite having established a national geotechnical society as well as producing geotechnical engineers through a graduate course, lacks proper geotechnical design guidelines for roads, bridges, and buildings. Natural hazards such as earthquakes, landslides, and floods, which frequently hit Nepal and are one of the major development hurdles in the country have also not been adequately studied and explored from geotechnical engineering perspective. It is therefore important that the research and technological knowhow the developed nations possess is transferred to the practicing nations. As a country in the central Himalaya, Nepal particularly suffers from frequent landslides and floods in annual basis, but the threat of a great earthquake, which is expected to hit any part of Nepal within the next 10-20 years is far greater than the decades of landslide and flood damages.

So as to deal with massive geotechnical challenges and bring into effect geotechnical engineering design and practices together with the development of education and re-

search in the country, Nepal Geotechnical Society (NGS) was formally registered with the Government of Nepal in 1993. Apart from various national seminars and guest lecture programs, we in NGS have been involved in international activities through our affiliation with the ISSMGE for more than a decade. Yet, following a few technical difficulties and at the same time largely retarded infrastructure development activities in the nation, we have not been able to exchange our experience with the international professionals and experts through any international events. Despite many attempts to hold an international event in Nepal, most of our activities have been willingly or unwillingly limited within the country. Among the Asian national geotechnical societies too, we have not been able to emerge as an active society in the region. With current membership strength of about 100, we are now trying to revive through various regular programs, and have planned to hold this international event in Nepal next year November together with ISSMGE ATC-3. As a first attempt to have an international scientific meet in the homeland, we have preferred to discuss our geotechnical concerns of geohazards with our international colleagues particularly because natural hazards are one of the important topics for geotechnical engineers and researchers in Nepal as well as in the world. The symposium organizing team requests you all to disseminate this information to all your colleagues and make everyone participate in this international event of geo-community.

### Aims and Objectives

Many Asian nations suffer every year from various kinds of natural disasters. Recent world disaster reports indicate that of the total annual disaster loss in the world, Asia alone contributes about 70%. In Asia too, the nations in the Pacific ring of fire and the Himalayan region are the ones that suffer the most in earthquake- and rain-induced natural disasters. Among the Himalayan region nations, Nepal probably suffers the most in annual basis, where in average about 200 people still lose their lives in landslides and floods. In addition, one estimation indicates that more than 50,000 people will be killed and hundreds of thousands will be injured mainly due to building collapse and fall of objects during an earthquake, which is expected to hit Nepal and the mid Himalayan region within the next 10-20 years. Past one decade of earthquake and tsunami disasters in the world has already claimed more than half a million people while landslides, floods, and volcanoes have also killed tens of thousands people all over the world. So, focusing on earthquake, landslides and floods, and related natural hazards, this international symposium is going to be organized with the following objectives.

- Bring together the world geo-community into a single forum and discuss science and engineering issues of geohazards for an appropriate and timely understanding as well as exchange of recent advances in research and practice.
- Provide a forum to the world geo-engineers and geoscientists to feel the situation of geohazard risk in the Himalayan region and to learn from the need of developing geosciences and geotechnical engineering so as to deal with the geohazards.
- Appeal to the world geo-community the activities of Nepal Geotechnical Society and ISSMGE ATC-3 and draw the world attention for an intensified development of geotechnical engineering and geosciences in Nepal.
- Appeal to the Nepalese government authorities as well as all stakeholders the need of strengthening geotechnical engineering design and construction guidelines not only in the field of geohazards but also in infrastructure development and construction activities.

### Technical Session Themes

Not restricting fully to the items listed below, this international symposium is being planned to encompass the following general technical session themes and subthemes.

#### 1. Earthquake

- Seismic design of geotechnical structures
- Liquefaction
- Ground improvement techniques
- Microtremor monitoring and damage prediction
- Physical and numerical models
- Case studies and field survey reports
- GIS technique and hazard/risk mapping

#### 2. Landslides and Flood

- Prevention design and practices
- Early warning techniques
- Monitoring and prediction
- Physical and numerical models
- Experiments and mechanism interpretations
- Case studies and field survey reports
- GIS technique and hazard/risk mapping

#### 3. Ground Subsidence

- Groundwater drawdown
- Flow simulation
- Physical models
- Subsidence prediction
- Case studies and field reports
- Preventive measures and practices

#### 4. Other geohazards and hazard management:

- High altitude rock slope failure
- Glacial lake outburst
- Rockfall hazard
- Hazard management practices
- Case studies

#### Inquiries and Communications

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URL: [www.ngeotechs.org/ngs/index.php/introduction](http://www.ngeotechs.org/ngs/index.php/introduction)



7th International Conference on Scour and Erosion (ICSE-7), 2<sup>nd</sup> – 4<sup>th</sup> December 2014, Perth, Western Australia, <http://www.2014icse.com>

Third Australasian Ground Control in Mining Conference 2014, Sydney, Australia, [www.mining.unsw.edu.au/node/608](http://www.mining.unsw.edu.au/node/608)

Proceedings of the Institution of Civil Engineers, Geotechnical Engineering, THEMED ISSUE 2015, Construction processes and installation effects, Editors: Benoît Jones, University of Warwick, UK and Stuart Haigh, University of Cambridge, UK, [sarah.walker@ice.org.uk](mailto:sarah.walker@ice.org.uk)



## IGS Chennai 2015

### 6<sup>th</sup> International Geotechnical Symposium on Disaster Mitigation in Special Geoenvironmental Conditions

January 21-23, 2015, IIT Madras, Chennai, India  
<http://igschennai.in/6igschennai2015>

The 6th International Geotechnical Symposium, 6IGS-Chennai, on "Geotechnical Engineering for Disaster Prevention & Reduction, Environmentally Sustainable Development" is organized by Indian Institute of Technology Madras and Indian Geotechnical Society, Chennai Chapter, with the support of Asian Technical Committee on Geotechnical Engineering for Natural Hazards (ATC-3) of ISSMGE. The associating organizations are, IGS Bangalore Chapter and IGS Kochi Chapter.

India has extensively developed its infrastructures in the recent years maintaining the balance between the nature and development. There have been natural disasters, some of them accelerated by these developments, leading to the formation of Ministry of Earth Sciences and National Disaster management Authority of India (NDMA) by Government of India. NDMA has done laudable services since then.

The symposium focuses on issues related to geotechnical aspects of disaster mitigation and control, providing a global perspective on current events and apprehension in the industry. It is sixth in the series of earlier conferences which was organized in various cities of Asia and Europe, including Incheon, South Korea (2013); Khabarovsk, Russia (2011); Harbin, China (2009); Yuzhno-Sakhalinsk, Russia (2007); Astana, Kazakhstan (2005).

India, having wide variety of natural features associated with uncertainty in monsoon winds and sudden fault movements, is highly prone to natural disasters. Droughts, floods, cyclones, landslides and earthquakes are the major types of disaster phenomena occurring in the region. Innumerable casualties and loss in public properties during recent events, such as Sikkim earthquake (2011) or cloud burst in Uttaranchal (2013), warrant the relevance of the symposium.

The symposium is organised in Chennai, a southern metropolis, situated on the eastern coast of India. The city is well connected with the rest of the world by an international airport. A good mixture of tradition and trendy culture, Chennai is currently a centre of many major infrastructure projects such as construction of underground metro, modernisation of airports and harbour facilities, highway projects etc.

#### SUB THEMES

##### 1. Geotechnical Problems related to Natural Hazards

- Advances in Geotechnical Earthquake Engineering
- Liquefaction Analysis and Mitigation
- Ground Improvement for Seismic Hazards
- Dynamic Analysis of Foundations and Retaining Walls
- Stability of Slopes and landslides
- Underground Space for Infrastructure

##### 2. Geoenvironmental Technology

- Recent Advances in Geoenvironmental Site Characterization
- Hydraulic Properties and Hydrology of Waste Containment Systems

- Reuse of Waste and Recycled Materials
- Advances in Heavy Metal Soil Treatment
- Geotechnics of Sediment Remediation and radioactive waste products
- Design of Landfill
- Case Histories in Geoenvironmental Engineering: Challenges and Innovation

##### 3. Field Instrumentation and Monitoring

- Advances of In-situ Testing Technologies
- Shear Wave Velocity Measurements using Surface Wave Methods
- Advances in Sensing/Monitoring Techniques during Geoconstruction

##### 4. Geotechnology under extreme environment

- Polar and Frozen Soil Engineering
- Estuary, Dams, and Coastal Erosion
- Tsunami: Prediction and Modelling

#### Address for Communication

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Geosynthetics 2015, February 15 – 18, 2015, Portland, Oregon, USA, <http://geosyntheticsconference.com>



#### 12th Australia New Zealand Conference on Geomechanics (ANZ 2015)

22-25 February 2015, Wellington, New Zealand  
<http://www.anz2015.com>

The New Zealand Geotechnical Society and the Australian Geomechanics Society proudly invite you to attend the 12th Australia New Zealand Conference on Geomechanics (ANZ 2015) which is the regional conference of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE) and is held approximately every 4 years. ANZ 2015 also warmly welcomes members of the International Association of Engineering Geologists (IAEG) and the International Society for Rock Mechanics (ISRM) to attend this regional event.

The last Australia New Zealand Conference held in Wellington, New Zealand was in 1980. Thirty-five years later, this event returns to Wellington, to a city and a world that is experiencing significant change and challenge resulting from human influence in our built environment.

As in 1980, our profession has the potential to shape and influence the future. For 2015, our conference theme is "The Changing Face of the Earth – Geomechanics & Human Influence". The worldwide community is currently facing great change; a changing climate, an evolving legislative environment and changing human perceptions and awareness of the cause and effects of our actions. This change presents an exciting series of risks and opportunities within our industry. This conference seeks to explore and better understand the drivers for changing our world and the impact we make – be this in marine and coastal areas or the built environment, from open cast mining to creating brand new communities.

ANZ 2015 will include the presentation of technical papers, keynote lectures, workshops, technical tours, exhibits, and social and networking opportunities for sponsors, participants and their partners. We especially encourage contributions from young professionals in our industry and there will be a prize awarded to the paper judged as best to be submitted by a young professional (under 35 years of age).

The overall Conference theme is The Changing Face of the Earth – Geomechanics & Human Influence. The theme reflects the fact that the worldwide community is currently facing great changes – catering for growing urban population and enhanced infrastructure requirements and expectations; and changing human perceptions and awareness of the effects of our actions particularly with respect to environmental impacts and risk of failure.

#### Contact Us

If you have any queries about the Conference arrangements please don't hesitate to contact us:

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Website: [www.tcc.co.nz](http://www.tcc.co.nz)



### 16th African Regional Conference on Soil Mechanics and Geotechnical Engineering April 27 to 30, 2015 in Hammamet, Tunisia <http://www.cramsg2015.org>

The Tunisian Association of Soil Mechanics (ATMS) is pleased to invite you to the 16th African Regional Conference on Soil Mechanics and Geotechnical Engineering to be held from April 27 to 30, 2015 in Hammamet, Tunisia. The conference will provide a forum for exchange and discussion between engineers, professionals, scientists, researchers, equipment or solution providers operating in the field of soil mechanics and geotechnical engineering. The ARMS is pleased to offer a warm welcome to the par-

ticipants and accompanying persons and to suggest an enriched and successful social program

The conference will provide to academicians and practitioners the opportunity to exchange the recent developments and to update the acquired knowledge in geotechnical engineering. This event mainly oriented towards specific challenges for Africa.

The conference will include keynotes, oral presentations and poster sessions. In addition, workshops and trainings will be scheduled.

A large exhibition is planned and will bring together the maximum of professional partners to animate the conference and allow participants from six continents to learn about the solutions offered by professionals and to respond their eventual concerns.

The conference will include a special session « ISP'7 » on the occasion of the 60th anniversary of Menard pressuremeter.

The main purpose of the conference is the study of African soils in all aspects: identification, characterization, study of behavior in connection with the design, implementation and monitoring of geotechnical structures.

Priority will be considered for soft soils, expansive soils, dune soils and lateritic soils.

The topics covered in the conference are: soil behavior, soil improvement, deep foundation and underground structures, seismic analysis and management of risks; landslides and environmental geotechnics.

The education and training of technicians in geotechnical engineering also represents a theme of priority during the 16th ARCMSG.

The Tunisian Association of Soil Mechanics

- Mehrez KHEMAKHEM (Chairman of Organization committee) [organisation@cramsg2015.org](mailto:organisation@cramsg2015.org) – [contact@cramsg2015.org](mailto:contact@cramsg2015.org)
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- Wissem Frikha (Logistics, Website and Chairman of Organization committee of ISP7 PRESSIO 2015) : [organisation@cramsg2015.org](mailto:organisation@cramsg2015.org), [ISP7\\_organisation@cramsg2015.org](mailto:ISP7_organisation@cramsg2015.org)



## ISP7-PRESSIO2015

27 to 30 April 2015, Hammamet, Tunisia

<http://www.cramsg2015.org/isp7-pressio2015>

This Symposium will be the seventh one "ISP7-PRESSIO2015" organized for the first time in Africa by the Tunisian Association of Soil Mechanics (ATMS) as part of the 16th African Regional Congress of Soil Mechanics and Geotechnical Engineering from 27 to 30 April 2015 in Hammamet, Tunisia.



## Symposium Aims

ISP7 will offer an opportunity to exchange experiences between contractors, manufacturers, engineers, scientists and academics.

The technical exhibition will help and permit to discover the latest methods and technologies and the most advanced testing equipments.

The exhibition is dedicated, among others, to the major actors of the ground improvement sector coming from both academic and professional worlds: research laboratories and universities, scientific societies, software companies, equipment manufacturers, private and public engineering consulting firms, with a special attention for the experts.

## Symposium Themes

The themes of symposium will be devoted to the following subjects:

- Equipment and methods
- Pressuremeter theory and Interpretation of the tests
- Applications to structures design
- Role of the pressuremeter in geotechnical engineering

The Symposium will include State of the Art lectures, sessions for oral presentations and poster sessions.

More information from the following address:

[ISP7\\_scientific@cramsg2015.org](mailto:ISP7_scientific@cramsg2015.org)



13<sup>th</sup> ISRM International Congress on Rock Mechanics Innovations in Applied and Theoretical Rock Mechanics 10-13 May 2015, Montreal, Canada, [www.isrm2015.com](http://www.isrm2015.com)



**World Tunnel Congress 2015  
and 41st ITA General Assembly  
Promoting Tunnelling in South East European  
(SEE) Region  
22 - 28 May 2015, Dubrovnik, Croatia  
<http://wtc15.com>**

Contact

ITA Croatia - Croatian Association for Tunnels and Underground Structures  
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**83rd ICOLD Annual Meeting  
June 2015, Stavanger, Norway**



ISFOG 2015 3<sup>rd</sup> International Symposium on Frontiers in Offshore Geotechnics, Oslo, Norway, 10-12 June 2015, [www.isfog2015.no](http://www.isfog2015.no)



**The 3<sup>rd</sup> International Conference on the Flat  
Dilatometer**

**Rome 15-17 June 2015  
<http://www.dmt15.com>**

The Technical Committee TC-102 of the International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE), the Italian Geotechnical Society (AGI) in cooperation with L'Aquila University are pleased to announce the 3<sup>rd</sup> International Conference on the Flat Dilatometer DMT'15 in Roma (Italy).

The previous two International Conferences on DMT were held in Edmonton Canada (1983) and in Washington D.C. (2006).

The 3<sup>rd</sup> International Conference on the Flat Dilatometer will be held June 15-17, 2015 at the Parco dei Principi Grand Hotel & SPA in Rome (Italy), steps away from Via Veneto, centre-stage of Fellini's Dolce Vita, overlooking Villa Borghese. Ancient Rome (Colosseum, Roman Forum etc etc) the Vatican and other sightseeing attractions are easily reached from the hotel.

The theme of the Symposium is the solution of geotechnical problems using the Flat Dilatometer Test (DMT), in particular settlement prediction and liquefaction evaluation. Other design applications include: compaction control, detecting slip surfaces in slopes, laterally loaded piles and other geotechnical problems using the soil parameters for which the DMT provides estimates.

Engineers, Consultants, Geologists, Researchers, Teachers and Students are invited to share their knowledge and experience. The technical and social program will provide an opportunity for meeting new contacts. The event will include an exhibition of equipments and services.

#### Conference Topics

- Settlement prediction
- Liquefaction evaluation and influence of stress history
- Compaction control
- Detecting slip surfaces in slopes
- Laterally loaded piles
- Diaphragm walls design
- FEM input parameters
- Stresses relaxation behind retaining structures
- Correlations and comparisons with other lab or in situ tests
- Seismic design (NTC08, Eurocode 8)
- In situ G-γ decay curves
- Other geotechnical problems using the soil parameters for which the DMT provides estimates.

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16<sup>th</sup> European Conference on Soil Mechanics and Geotechnical Engineering "Geotechnical Engineering for Infrastructure and Development", 13 - 17 September 2015, Edinburgh, UK, [www.xvi-ecsmge-2015.org.uk](http://www.xvi-ecsmge-2015.org.uk)

Workshop on Volcanic Rocks & Soils, 24 - 25 September 2015, Isle of Ischia, Italy, [www.associazionegeotecnica.it](http://www.associazionegeotecnica.it)



#### **EUROCK 2015** **ISRM European Regional Symposium** **64th Geomechanics Colloquy** **7 - 9 October 2015, Salzburg, Austria**



#### **International Conference in** **Geotechnical Engineering - Colombo- 2015** **10 - 11 August 2015, Colombo, Colombo, Sri Lanka** <http://www.slgs.lk/?p=564>

International Conference in Geotechnical Engineering - ICGE-Colombo 2015, organized by the Sri Lankan Geotechnical Society (SLGS) will be held on 10th and 11th August 2015 at Cinnamon Grand Colombo.

The conference would be held with parallel sessions over two days followed by a technical field trip.

Preliminary list of themes attached would be combined to form conference sessions. Several keynote speakers would be identified to cover areas of greater interest. There will be an inauguration session on the morning of day 1 and a short closing ceremony in the evening of day 2.

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Further details on the conference and the Sri Lankan Geotechnical Society in general can be obtained from our website [www.slgs.lk](http://www.slgs.lk).



#### **6th International Conference on** **Earthquake Geotechnical Engineering** **2-4 November 2015, Christchurch, New Zealand,** [www.6icege.com](http://www.6icege.com)

I am delighted to invite you to join us at the 6th International Conference on Earthquake Geotechnical Engineering (6ICEGE) in Christchurch, New Zealand, 2-4 November 2015. Following the highly successful conferences in Tokyo 1995, Lisbon 1999, Berkeley 2004, Thessaloniki 2007 and Santiago 2011, this will be the sixth in the series of specialized conferences organized under the auspices of The Technical Committee on Earthquake Geotechnical Engineering (TC203) of ISSMGE.

Christchurch, the second largest city of New Zealand, was hit by a series of destructive earthquakes in 2010 and 2011 causing 185 fatalities and extensive damage to the buildings and lifelines of Canterbury (~\$40 billion New Zealand dollars loss). While undoubtedly the earthquakes had many engineering, scientific and social facets, one may argue that from an engineering viewpoint the 2010-2011 earthquakes were largely geotechnical in nature, and were dominated by the unprecedented impacts from soil liquefaction and rock-falls over nearly half of the city area. Christchurch is now embarking on a large reconstruction project in which ground improvement, foundation engineering and restoration of lifelines comprise a substantial component of the \$40 billion NZD rebuild effort. Indeed, Christchurch provides an exceptional context and venue for the 6ICEGE.

We believe the 6ICEGE will provide an excellent opportunity for earthquake and geotechnical engineers, geologists and seismologists, consulting engineers, public and private contractors, city and national authorities, and all those involved with engineering works and research related to earthquake geotechnical engineering, to exchange ideas and present their recent experience and developments.

With your active participation in the 6ICEGE, this coming conference will also be a successful event where you will be professionally rewarded and at the same time you will enjoy New Zealand's stunning natural and cultural beauty.

I look forward to welcoming you to Christchurch – The Garden City - in November 2015.

Prof Misko Cubrinovski  
Conference Chairman  
University of Canterbury, Christchurch, New Zealand

#### Conference Topics

- 01 Soil dynamics: field and laboratory testing
- 02 Soil-site characterization and dynamic soil modelling
- 03 Site effects and microzonation
- 04 Seismic hazard and strong ground motion
- 05 Soil liquefaction and lateral spreading
- 06 Impacts of liquefaction on buildings and infrastructure
- 07 Slopes, embankments, dams and landfills
- 08 Earth-retaining and waterfront structures
- 09 Shallow and deep foundations
- 10 Residential and multi-storey buildings
- 11 Underground structures and waste repositories
- 12 Lifeline earthquake engineering
- 13 Offshore structures, critical facilities
- 14 Soil-structure-foundation interaction
- 15 Analytical and numerical methods
- 16 Case histories, observations and lessons from recent and past earthquakes
- 17 Codes, policy issues, insurance and standard of practice
- 18 Geotechnical engineering for mega-earthquakes and multi-hazards
- 19 Geotechnical engineering for urban systems and resilient communities
- 20 Performance-based design in earthquake geotechnical engineering

For any queries about the Conference arrangements please contact:

#### 6th International Conference on Earthquake Geotechnical Engineering

Conference Managers: [The Conference Company](http://www.theconferencecompany.co.nz)

PO Box 3727, Christchurch, New Zealand

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The 15th Asian Regional Conference on Soil Mechanics and Geotechnical Engineering, 9-13 November 2015, Fukuoka, Japan, <http://www.15arc.org>



#### 15th Pan-American Conference on Soil Mechanics and Geotechnical Engineering 15 - 18 November 2015, Buenos Aires, Argentina <http://conferencesba2015.com.ar>

The Argentinian Geotechnical Engineering Society (SAIG) is pleased to announce that it will be the host of the 15th Pan-American Conference on Soil Mechanics and Geotechnical Engineering (XV PCSMGE), to be held in Buenos Aires (Argentina) from 15th to 18th November 2015.

From the first Pan-American Conference in Mexico in 1959, the Pan-American Conferences have been held every four years in different countries of the Americas: Brazil 1963, Venezuela 1967, 1971 Puerto Rico, Argentina 1975, 1979 Peru, 1983 Canada, 1987 Colombia, Chile 1991, Mexico 1995, Brazil 1999, 2003 USA, 2007 Venezuela, 2011 Canada.

This time, PCSMGE XV – Buenos Aires 2015 will coincide with three important events for geo – professionals: the 8th South American Conference on Rock Mechanics (CSMR), the 6th International Symposium of Deformation Characteristics of Soils (IC- BA2015) and the XXII Argentinian Congress of Soil Mechanics and Geotechnical Engineering (CAMSIG XXII). This meeting will bring together international experts, researchers, academics, professionals and geoenvironmental companies in a unique opportunity to exchange ideas and discuss current and future practices in the areas of soil mechanics, rock mechanics, and their applications in civil, mining and environmental engineering,

Buenos Aires is a charming city where history and modernity converge. Variety of sights, museums and cultural events are combined with an eclectic cuisine and a great variety of night entertainment. XV PCSMGE 2015 will be held at the Hilton Hotel in a fashionable and exclusive area of the city with access to all major tourist attractions and good connection with domestic and international airports. We aim and dream to produce an event that will strengthen the unity between academics and geo- practitioners from the Americas. We hope to see you in Buenos Aires 2015 to celebrate together this great event for our profession.

#### TOPICS

- A – Transportation geotechnics
- B – In situ testing
- C – Geo-Engineering for Energy and Sustainability
- D – Numerical modelling in Geotechnics
- E – Foundations & ground improvement
- F – Unsaturated soils
- G – Embankments, dams and tailings
- H – Excavations and tunnels
- I – Geo-Risks
- J – Geo-Education
- K – Laboratory testing

#### SECRETARIA GENERAL | MCI ARGENTINA

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### VIII South American Congress on Rocks Mechanics

15 - 18 November 2015, Buenos Aires, Argentina

<http://conferencesba2015.com.ar>

#### TOPICS

- A – Rock mechanics for Mining
- B – Rock mechanics for Infrastructure
- C – Rock mechanics for Oil & Gas
- D – Testing methods & monitoring
- E – Design & analysis methods
- F – Hydrogeology of rock mass

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Sixth International Conference on Deformation Characteristics of Geomaterials IS Buenos Aires 2015, November 15th to 18th 2015, [www.saiq.org.ar/ISDCG2015](http://www.saiq.org.ar/ISDCG2015)

2015 6<sup>th</sup> International Conference Recent Advances in Geotechnical Engineering and Soil Dynamics, December 7-11, 2015, New Delhi (NCR), India, [wason2009@gmail.com](mailto:wason2009@gmail.com); [wasonfeq@iitr.ernet.in](mailto:wasonfeq@iitr.ernet.in), [sharmamukat@gmail.com](mailto:sharmamukat@gmail.com); [mukutfeq@iitr.ernet.in](mailto:mukutfeq@iitr.ernet.in), [gvramanaiitdelhi@gmail.com](mailto:gvramanaiitdelhi@gmail.com), [ajaycbri@gmail.com](mailto:ajaycbri@gmail.com)



### 3<sup>rd</sup> PanAmerican Regional Conference on Geosynthetics

11-14 April 2016, Miami South Beach, USA

[NAGSDirector05@gmail.com](mailto:NAGSDirector05@gmail.com)



**84th ICOLD Annual Meeting**  
May 2016, Johannesburg, South Africa



### GEOSAFE: 1st International Symposium on Reducing Risks in Site Investigation, Modelling and Construction for Rock Engineering - an ISRM Specialized Conference

25 – 27 May 2016, Xi'an, China

#### Contact

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NGM 2016 - The Nordic Geotechnical Meeting, 25 - 28 May 2016, Reykjavik, Iceland, [www.ngm2016.com](http://www.ngm2016.com)



### 3<sup>rd</sup> ICTG International Conference on Transportation Geotechnics

4 - 7 September 2016, Guimarães, Portugal

The Transportation Geotechnics International Conference series began under the auspices of ISSMGE-TC 3 and was initiated in 2008 at the University of Nottingham, UK, as an International event designed to address the growing requirements of infrastructure for societies. The 2<sup>nd</sup> International Conference on Transportation Geotechnics took place in 2012, at Sapporo, Japan, under the ISSMGE-TC202 that follows the TC-3 activities for the period 2009-2013. To continue the successful of these conferences and the output of ISSMGE-TC-202, the 3<sup>rd</sup> was scheduled for 2016, at Guimarães, Portugal. Following the previous one, the challenges addressed by this conference will include a better understanding of the interactions of geotechnics on roads, rails, airports, harbours and other ground transportation infrastructure with the goal of providing safe, economic, environmental, reliable and sustainable infrastructures. The 3<sup>rd</sup> ICTG will be composed of workshops and several types of sessions, as well as a technical exhibition, to better disseminations of findings and best practices. A special attention will be paid to the publication of all the peer review papers, some of them in specialised international journals. On behalf of the organizing committee I am honoured to invite you to the 3<sup>rd</sup> ICTG in the City of Guimarães, UNESCO World Heritage (September 4-7, 2016).



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**EuroGeo 6 – European Regional Conference  
on Geosynthetics**  
25 – 29 Sep 2016, Istanbul, Turkey  
[eguler@boun.edu.tr](mailto:eguler@boun.edu.tr)



**6<sup>th</sup> Asian Regional Conference  
on Geosynthetics**  
November 2016, New Delhi, India  
[uday@cbip.org](mailto:uday@cbip.org)



**11<sup>th</sup> International Conference on Geosynthetics  
(11ICG)**  
16 - 20 Sep 2018, Seoul South Korea  
[csvoo@skku.edu](mailto:csvoo@skku.edu)

## Bertha's nemesis: 119-foot steel pipe

Highway 99 contractors revealed Friday what's been blocking Bertha, the giant tunnel machine: The obstruction is steel pipe, left buried by a state groundwater study in 2002.



A fragment of steel pipe pokes between spokes of Bertha's cutting face, in this photo from Thursday's inspection. It's part of a 119-foot deep well, left in the soil after a 2002 groundwater test.

State officials revealed Friday that the mystery object blocking tunnel machine Bertha is a long steel pipe, left buried in 2002 by one of the Highway 99 project's own research crews.

The tunnel drill has been stranded for a month near Pioneer Square, with no clear strategy yet to extract the pipe.

The Department of Transportation (DOT) could not estimate how much time and money it will take to get the world's largest drill moving again.

Bertha's cutting teeth struck the pipe Dec. 3, yet the DOT and its contractors avoided mentioning the steel as a possible culprit for four weeks, despite an incident in which the machine knocked a 55-foot pipe fragment to the surface.

What the ongoing delay means for taxpayers is unclear, but it's certainly not good.

The costs will be determined later through negotiations between the state and Seattle Tunnel Partners (STP), maybe even a legal dispute.

The \$2 billion tunnel budget includes a \$40 million risk allowance for repairs and inspections near the front of the rotary cutting face — plus a \$105 million general contingency fund to deal with crises. Matt Preedy, deputy Highway 99 administrator for the state Department of Transportation, said some of that money will be consumed.

The culprit is an 8-inch diameter, 119-foot-long well casing, used to measure groundwater for the Alaskan Way Viaduct

replacement project, officials said. Back then, a shallow cut-and-cover tunnel was a leading option.

A jagged piece of the pipe appeared Thursday night, after enough groundwater was pumped out of the machine and soil to allow STP crews a view through the cutting face.

The 2002 well site was listed in reference materials provided to construction bidders, as part of the contract specifications.

"I don't want people to say WSDOT didn't know where its own pipe was, because it did," said state spokesman Lars Erickson.

However, Chris Dixon, STP's project director, said the builders presumed it had been removed.

"If we had known the pipe was there, we would have removed it," he said.

Dixon mentioned that Ecology Department rules require well casings to be removed after use. Ecology spokesman Dan Partridge said his department didn't perform the viaduct studies, and as a general rule, "you do not necessarily have to remove a casing when you remove a well."

Bertha first encountered the pipe Dec. 3, Dixon said. The clockwise cutting motion pushed part of it above the surface, and fragments showed up in a conveyor system within the machine, he said.

"We saw a pipe come up, out of the ground 6 or 7 feet," he said. "We continued mining, successfully."

Workers removed a 55-foot-long piece, he said. For two days, the drill moved along fine, creating what Dixon called "a false sense of security."

The blockage, which Bertha hit 60 feet below surface, is beneath the area where Seattle settlers dumped fill soil and debris, based on local histories. No metal should be there.

So why didn't that bizarre pipe hit scare Dixon into halting immediately Dec. 3? He replied Friday the team didn't realize the pipe extended so deep, and thought workers had removed it all.

On Dec. 6, the cutter turned without grabbing soil. So the operators quit running it the next morning, to avoid harming the \$80 million machine.

A modern tunnel machine can chew through dirt, rocks and concrete, but not steel, which can become tangled in the cutting head, or caught in a conveyor screw. Dixon said Friday that "we don't know" yet whether any moving parts are jammed.

However, the team has found unusual wear on block-shaped cutting tools, and STP is replacing those with new tools on the cutting head.

For the last four weeks, DOT didn't mention steel pipe as a suspect, and even talked about the cutting-tool swap on Monday as routine. In a Dec. 20 blog post, removed Friday, the DOT said, "We simply don't know yet" the cause.

Asked about this, Preedy said Friday that initially, the team gave DOT and outside tunnel experts information about the pipe strike.

"In that same two days, there were pieces of boulder that had come out on the [conveyor] belt," he said. The experts thought the chance of further problems with pipe were low, he said. "At that point in time, we were pretty well convinced it was something else," Preedy said. For instance, a giant rock deposited by glaciers.

The theory changed this week when vertical-test probes hit small objects, then Thursday's inspection located buried pipe, he said.

Construction of the four-lane tunnel is three months behind its schedule to be open at the end of 2015.

However, the machine in November was advancing as fast as 50 feet a day, prompting Preedy to say it's possible to regain time after the steel is removed.

This incident follows other woes at DOT, including an expensive crack repair and delay for Highway 520 bridge pontoons; staff shortages that canceled late-summer ferry runs; and the loss of \$175 million in planning costs for the Interstate 5 Columbia River Crossing, before work was halted by a legislative impasse.

On the positive side, work is proceeding smoothly on rebuilding Interstate 90 east of Snoqualmie Pass, and the DOT quickly replaced a downed Skagit River Bridge span.

Quite a bit of work remains to clear the pipe away from Bertha.

Thursday's inspection included only the top 15 feet of the machine because the rest is flooded with mud and groundwater. STP must somehow check the lower 42 feet of the 57-foot diameter face, perhaps with tunnel-trained divers.

Then the steel must be extracted from above, going through unstable soil, or from within the cutter face.

Dixon said contractors are trying to figure out what methods are possible, while protecting worker safety.

(Mike Lindblom / The Seattle Times, January 3, 2014, [http://seattletimes.com/html/localnews/2022593902\\_bertha\\_metal.xml.html](http://seattletimes.com/html/localnews/2022593902_bertha_metal.xml.html))



### Η μεγαλύτερη εδώ και αιώνες Τερατώδης κατολίσθηση προκάλεσε γδούπο 2.5 Ρίχτερ

Ήταν πιθανότατα η μεγαλύτερη μη ηφαιστειακή κατολίσθηση στη σύγχρονη ιστορία της Βόρειου Αμερικής. Περίπου 65 εκατομμύρια κυβικά μέτρα πετρωμάτων κατρακύλησαν στο λάκκο ενός ανοιχτού ορυχείου στη Γιούτα, απελευθερώνοντας ενέργεια που αντιστοιχεί σε σεισμό 2,5 βαθμών της κλίμακας Ρίχτερ. Λίγο μετά το γδούπο, ακολούθησαν ασθενείς αλλά πραγματικοί σεισμοί.

Η κατολίσθηση στο ορυχείο χαλκού Μπίνγκχαμ Κάνιον «μετακίνησε αρκετό έδαφος για να καλύψει το Σέντραλ Παρκ της Νέας Υόρκης σε βάθος 20 μέτρων» **αναφέρουν** ερευνητές του Πανεπιστημίου της Γιούτα στο GSA Today, μια επιθεώρηση της Γεωλογικής Εταιρείας Αμερικής.

Ο λάκκος του ορυχείου, περίπου 30 χιλιόμετρα από το Σολτ Λέικ Σίτι της Γιούτα, έχει διάμετρο 4,5 χιλιόμετρα και βάθος ένα χιλιόμετρο. Σύμφωνα μάλιστα με την ιδιοκτήτρια εταιρεία, είναι η μεγαλύτερη ανασκαφή στον κόσμο.

Στις 10 Απριλίου 2013, το έδαφος στην κορυφή του λάκκου υποχώρησε σε δύο κύματα, με διαφορά περίπου 90 λεπτών. Και στις δύο περιπτώσεις, σαθρά πετρώματα κατρακύλησαν μέχρι τον πυθμένα του λάκκου, αναπτύσσοντας ταχύτητα μέχρι 170 χιλιόμετρα την ώρα.

Οι κατολισθήσεις δεν ήταν βέβαια σεισμοί, καταγράφηκαν όμως από σεισμόμετρα ως δονήσεις ισχύος 2,5 και 2,4 βαθμών στην κλίμακα Ρίχτερ. Οι πραγματικοί σεισμοί που καταγράφηκαν λίγο μετά την κατολίσθηση ήταν πολύ ασθενέστεροι και απελευθέρωσαν ενέργεια που αντιστοιχεί χονδρικά σε μια χειροβομβίδα.



Σαθρά πετρώματα κατρακύλησαν μέχρι τον πυθμένα του ορυχείου με ταχύτητα έως 170 χλμ/ ώρα

Σύμφωνα μάλιστα με τους ερευνητές, είναι η πρώτη φορά που μια κατολίσθηση προκαλεί επιβεβαιωμένα σεισμούς.

Περίπου 65 εκατομμύρια κυβικά βράχου, ποσότητα που αντιστοιχεί σε 21 πυραμίδες του Χέοπα στην Αίγυπτο, μετατοπίστηκαν μέσα στο ορυχείο.

Ήταν πιθανότατα η μεγαλύτερη μη ηφαιστειακή κατολίσθηση που καταγράφεται στη Βόρεια Αμερική εδώ και αιώνες, ωστόσο χωρίς σε σχέση με την ηφαιστειακή κατολίσθηση στο Όρος της Αγίας Ελένης το 1980, η οποία εκτιμάται από την ερευνητική ομάδα ότι ήταν 57 φορές μεγαλύτερη.

(Newsroom ΔΟΛ, 08 Ιαν. 2014, <http://news.in.gr/science-technology/article/?aid=1231285564>)

(βλέπε και σχετικό άρθρο στην σελίδα 6)



### Χωριό κοντά στην Αρχαία Ολυμπία κόπηκε στα δύο



Με τον εφιάλτη των καθιζήσεων και των κατολισθήσεων ζουν οι κάτοικοι της Καυκανιάς, κοντά στην Αρχαία Ολυμπία, που βλέπουν το χωριό τους να κόβεται στα δύο και τη γη που υποχωρεί, να απειλεί περιοχές. Όπως ανέφεραν κάτοικοι της Καυκανιάς, κατά τη διάρκεια των προχθεσινών κατολισθήσεων «όλος ο τόπος έτριξε, ακούγονταν κρότοι και



στη συνέχεια άρχισαν να πέφτουν κεραμίδια». Το φαινόμενο των καθιζήσεων, σύμφωνα με τους κατοίκους, πρωτοεμφανίστηκε τον Φεβρουάριο του 2013, επαναλήφθηκε την περασμένη Κυριακή και εντάθηκε τα ξημερώματα της Τετάρτης. Επειτα από έντονες βροχοπτώσεις τρία σπίτια, ένα καφενείο και ο κεντρικός δρόμος υπέστησαν σοβαρές ζημιές.



Το φαινόμενο των καθιζήσεων στην Καυκανιά πρωτοεμφανίστηκε τον Φεβρουάριο του 2013, επαναλήφθηκε την περασμένη Κυριακή και εντάθηκε ξημερώματα Τετάρτης.

Συγκεκριμένα, ο κεντρικός δρόμος έχει υποστεί καθίζηση σε δύο σημεία, με αποτέλεσμα να είναι αδιάβατος. Επίσης ένα ισόγειο οίκημα, όπου στεγάζεται καφενείο, έχει υποστεί ζημιές στην τοιχοποιία και στη στέγη, ενώ έχουν «χτυπηθεί» και τρία γειτονικά σπίτια.

Χθες το πρωί επισκέφθηκε την Καυκανιά κλιμάκιο μηχανικών της περιφέρειας και έκανε αυτοψία στην περιοχή, ενώ τις επόμενες ημέρες αναμένεται να συνταχθεί πόρισμα, για τον τρόπο με τον οποίο μπορεί να αντιμετωπιστεί το φαινόμενο. «Περιμένουμε το πόρισμα των μηχανικών, το οποίο θα καθορίσει τις δικές μας ενέργειες. Πρόκειται για ένα φαινόμενο που απαιτεί εξειδικευμένη αντιμετώπιση» είπε ο δήμαρχος Αρχαίας Ολυμπίας Ευθύμιος Κοτζιάς. Επιχειρώντας να δώσει μία πρώτη εξήγηση για το φαινόμενο, ανέφερε πως η κατολίσθηση πιθανώς να οφείλεται σε υλικά που ολισθαίνουν στο υπέδαφος με τη βοήθεια του νερού. Γι' αυτό, όπως πρόσθεσε, θα χρειαστεί να γίνουν γεωτρήσεις.

Σχετικά με τους ιδιοκτήτες του καφενείου και των σπιτιών που έχουν υποστεί ζημιές, ο Ευθύμιος Κοτζιάς τόνισε ότι «θα απευθυνθούμε στις αρμόδιες υπηρεσίες, ώστε να ενταχθούν σε πρόγραμμα αντίστοιχο με αυτό των σεισμοπαθών ή των πυροπαθών, για να πάρουν δάνεια και να μπορέσουν να φτιάξουν τα σπίτια τους σε άλλο σημείο του χωριού».

(Ηλίας Κάνιστρας / Η ΚΑΘΗΜΕΡΙΝΗ, 31.01.2014, <http://www.kathimerini.gr/751434/article/epikairothta/ella-da/xwrio-konta-sthn-arxaia-olympia-kophke-sta-dyo>)



### Wholly outrageous: Family flees home after sinkhole swallows car

**A teenager woke up to find her car at the bottom of a hole that had appeared overnight in her family's driveway.**

Zoe Smith, 19, fled to safety with her mother and stepfather after discovering her Volkswagen Lupo – parked right outside the window – had been swallowed up.

The family were left fearing their home could also disappear after the 9m (30ft)-deep hole opened without warning. It may have been caused by heavy rain eroding earth used to fill in old clay pits in Walter's Ash, Buckinghamshire.



The Buckinghamshire family fled their home after the shocking discovery

Zoe's stepfather Phil Conran, a 59-year-old environmental consultant, said: 'We hadn't heard anything at all. There was no indication whatsoever.

'Zoe went out the front door and instead of her car being there, there was a huge hole.'

Firefighters were called at 8.32am yesterday to find that the car had vanished in a hole with a diameter of 15ft. Luckily nobody was in it at the time.

A Buckinghamshire Fire and Rescue Service spokesman said: 'Firefighters placed a cordon around it and gave safety advice.

'The incident was handed over to building control at Wycombe District Council. Firefighters were at the scene for about an hour.'

(Metro News Reporter Monday 3 Feb 2014, <http://metro.co.uk/2014/02/03/wholly-outrageous-family-flees-home-after-sinkhole-swallows-car-4288534>)





## Ηλεία: Εκτεταμένα προβλήματα σε Βούναργο και Κατάκολο από κατολισθήσεις - Συναγερμός για υπερχείλιση του Αλφειού



Μεγάλης έκτασης τα προβλήματα που έχουν σημειωθεί στην Ηλεία, εξαιτίας των έντονων βροχοπτώσεων των τελευταίων ημερών. Επί ποδός τοπικές αρχές για την αντιμετώπιση τους. Στο Κατάκολο βουνό «στέκει» απειλητικά πάνω από σπίτια, στο Βούναργο υποχώρησε το έδαφος, παρασύροντας δρόμους και δεξαμενές υδροδότησης, ενώ συναγερμός έχει σημάνει υπό το φόβο υπερχείλισης του Αλφειού.

**Βούναργο:** Υποχώρησε το έδαφος- Η γη «κατάπιε» δρόμους και δεξαμενές!

Την περιοχή που σημειώθηκε η μεγάλη κατολίσθηση που παρέσυρε δρόμο και δεξαμενές νερού στο Βούναργο, επισκέφθηκε χθες ο Δήμαρχος Πύργου Μάκης Παρασκευόπουλος. «Δεν υπήρχε καμία προηγούμενη ένδειξη. Είναι ένα φαινόμενο που μας είχε αιφνιδιάσει όλους θα το αντιμετωπίσουμε. Η έκτασή του είναι μεγάλη σε όλη την πλαγιά. Έχει μετακινηθεί ολόκληρο το τμήμα του βουνού».



Ο Δήμαρχος μαζί με συνεργάτες του, είδαν την κατάσταση, έκαναν λόγο για εκτεταμένο φαινόμενο που έχει προκαλέσει πολύ μεγάλες ζημιές και τόνισε πως άμεση προτεραιότητα είναι η αποκατάσταση της υδροδότησης άμεσα.

Ο Αντιδήμαρχος Τεχνικών Υπηρεσιών Βασίλης Παναγόπουλος, ανέφερε ότι «αυτό το γεωλογικό φαινόμενο στο Βούναργο είναι πιο σοβαρό από αυτό στο Κατάκολο, διότι έχει ενεργοποιηθεί μια ολίσθηση η οποία είχε ως αποτέλεσμα να καταστραφεί ένας επαρχιακός δρόμος και να καταστραφεί και η υδροδότηση του χωριού».

Πολλά τα προβλήματα που προκλήθηκαν από τα έντονα καιρικά φαινόμενα, και έχει να αντιμετωπίσει ο Δήμος Ανδρίτσαινας – Κρεστένων.

«Άνοιξε» η γη στον κεντρικό οδικό άξονα Κρέστενας – Ανδρίτσαινας, ενώ μεγάλες είναι οι καταστροφές που σημειώθηκαν στο οδικό δίκτυο της περιοχής με τους κατοίκους να μιλούν για πρωτοφανή φαινόμενα.

Καθίζηση στο ένα ρεύμα κυκλοφορίας με την γη να «καταπίνει» την ασφαλτο, σημειώθηκε στον δρόμο που οδηγεί από την γέφυρα του Αλφειού προς τα Άσπρα Σπίτια.

Στην Ε.Ο. Κρέστενας – Ανδρίτσαινας υπήρξαν νέες κατολισθήσεις και πτώσεις βράχων στο ύψος της Πλατιάνας, ενώ στην είσοδο του Γραίκα υποχώρησε εκ νέου τμήμα του δρόμου σε νέα καθίζηση.

Όπως ανέφεραν στην «Πρωινή» οι αντιδήμαρχοι Δήμος Φωτεινόπουλος και Γιάννη Δάγκαρης τα προβλήματα είναι πολλά και διάσπαρτα στις περιοχές του Δήμου.

**Κατάκολο:** Σπίτια «απειλούνται» από κατολισθήσεις!

Υπό τον φόβο νέας κατολίσθησης ζουν οι κάτοικοι στο Κατάκολο, τα σπίτια των οποίων κινδυνεύουν από την «πτώση» βουνού.

Στην περιοχή τα κατολισθητικά φαινόμενα εξαιτίας των έντονων βροχοπτώσεων σημειώθηκαν το βράδυ του περασμένου Σαββάτου.

Συνεργεία του Δήμου και της Πολιτικής Προστασίας, το πρωί της Κυριακής καθάρισαν το χώρο, όμως ο δρόμος παραμένει κλειστός για την κυκλοφορία πεζών και οχημάτων λόγω του κινδύνου να υπάρξει και νέα κατολίσθηση στο σημείο.



### Φόβος υπερχείλισης του Αλφειού!

Συναγερμός έχει σημάνει στις αρμόδιες αρχές για το ενδεχόμενο υπερχείλισης του Αλφειού, καθώς η στάθμη του ποταμού φαίνεται να ανεβαίνει επικίνδυνα.





Ο ποταμός, έχει δημιουργήσει αρκετά προβλήματα προκαλώντας πλημμύρες σε καλλιεργήσιμες εκτάσεις, ενώ η στάθμη του διαρκώς ανεβαίνει. Είναι χαρακτηριστικό πως ο Αλφειός ενισχύεται διαρκώς από τα νερά του Ερυμάνθου, του Ενιπέα και άλλων μικρότερο παραπόταμων και χειμάρρων. Η στάθμη του έχει ανέβει αρκετά και στις περιοχές κάτω από το φράγμα του Φλόκα στην Αλφειούσα, όπου πλημμύρισαν και εκεί οι παρόχθιες εκτάσεις.

(patratora.gr, 5 Μαρτίου 2014,  
<http://patratora.gr/archives/1553>)

### Ηλεία: Εικόνες βιβλικής καταστροφής στο Βούναργο



Χθες το πρωί, ο Περιφερειάρχης Δυτικής Ελλάδας Απόστολος Κασιφάρας μαζί με τον Αντιπεριφερειάρχη Ηλείας Χαράλαμπο Καφύρα, τον Δήμαρχο Πύργου Μάκη Παρασκευόπουλο, Περιφερειακούς Συμβούλους, κλιμάκιο επιστημόνων και διευθυντές των Τεχνικών Υπηρεσιών της Περιφέρειας, έκανε αυτοψία στα δύο σημεία της Ηλείας, όπου το εκτεταμένο αυτό φαινόμενο έχει προκαλέσει μεγάλες ζημιές.

Αναφορικά με το Βούναργο, ο κ. Κασιφάρας ανακοίνωσε πως ήδη εξασφαλίστηκαν τα χρήματα από τους ελάχιστους πόρους που διαθέτει η Περιφέρεια Δυτικής Ελλάδας, προκειμένου με προγραμματική σύμβαση με τη Δημοτική Αρχή Πύργου, να προχωρήσει η εκπόνηση γεωλογικής και τεχνικής μελέτης και στη συνέχεια να γίνουν άμεσα οι όποιες παρεμβάσεις χρειάζονται.

Σχετικά με το Κατάκολο, θα υπάρξει άμεσα επικοινωνία με το Ινστιτούτο Γεωλογικών και Μεταλλευτικών Ερευνών (ΙΓΜΕ), καθώς και καθηγητές του Πανεπιστημίου Πατρών, αφού το πρόβλημα στο συγκεκριμένο σημείο είναι αρκετά πιο σοβαρό απ' ό,τι δείχνει αρχικά και θα πρέπει η μελέτη που θα γίνει και οι παρεμβάσεις να είναι επιστημονικά επαρκείς και να δίνονται τεχνικά οι πρέπουσες λύσεις.



«Δυστυχώς δεν μπορούμε να παραβλέψουμε πως το τελευταίο χρονικό διάστημα, όλο και περισσότερες περιοχές της Περιφέρειας Δυτικής Ελλάδας "υποφέρουν" συχνά από κατολισθήσεις. Δεν είναι η πρώτη φορά που συναντάται αυτό το φαινόμενο, αντίστοιχα προβλήματα παρουσιάζονται και στην Αιτωλοακαρνανία και στην Αχαΐα, αλλά και σε άλλες περιοχές της Ηλείας. Μέλημά μας είναι με τις τεχνικές μας υπηρεσίες και τους ειδικούς επιστήμονες να προσπαθήσουμε να αντιμετωπίσουμε αυτό το σοβαρό ζήτημα που στις περισσότερες των περιπτώσεων έχει σημαντικές επιπτώσεις στη ζωή των πολιτών μας. Και οι δύο αυτές περιοχές, το Βούναργο και το Κατάκολο, είναι μείζονος σημασίας για εμάς και θα παρέμβουμε για να προστατεύσουμε τους πολίτες μας» υπογράμμισε ο Περιφερειάρχης Απ. Κασιφάρας προσθέτοντας: «Βρισκόμαστε δίπλα τους και θα κάνουμε ό,τι είναι δυνατόν προκειμένου να διασφαλίσουμε τις περιουσίες, τα σπίτια τους αλλά και τους ιδίους, ώστε να μην κινδυνεύουν και πάλι με τα ακραία καιρικά φαινόμενα».



(patratora.gr, 6 Μαρτίου 2014,  
<http://patratora.gr/archives/1751>)



### Railroad retaining wall collapses in Charles Village

No injuries reported as parked cars topple into a CSX right-of-way along 26th Street. Was this a collapse waiting to happen?

Lee Truelove, who lives on East 26th Street opposite the deep gully used by CSX trains, saw it happen.

"At about 3:30 p.m., the cars on that side [of the street] went about three feet down. And the wall began to tip," Truelove said, standing at the St. Paul Street intersection in the driving rain. She called 911 and the railroad, she said, and alerted her neighbors to come look.

"Then 15 minutes later, the whole thing just went," she said. "It was gone in 15 seconds." Truelove called the landslide both "exciting and creepy."

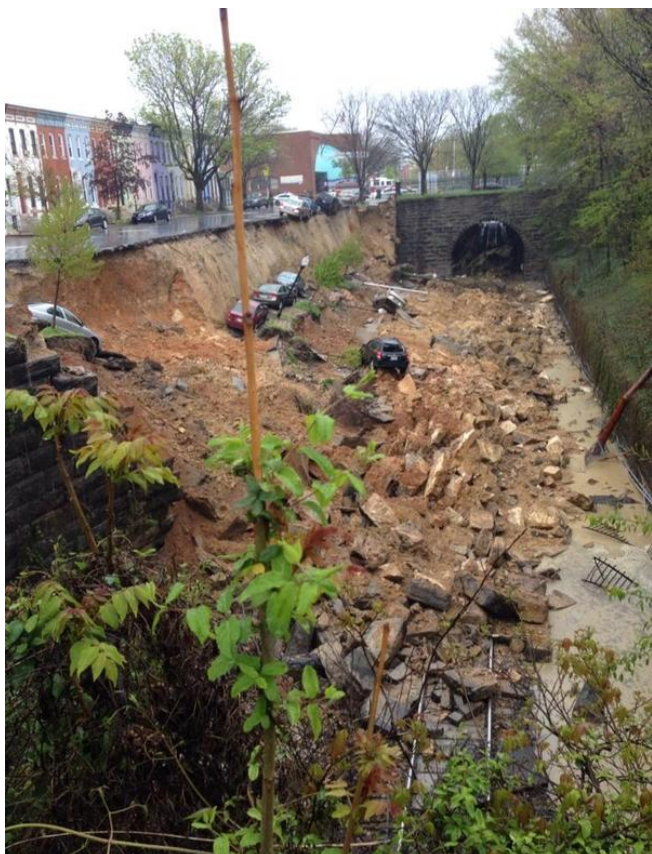
Close to a dozen parked cars – together with the retaining wall, concrete sidewalk, iron fence and lone street light – slid down the embankment, burying the tracks in debris.

### Like an Earthquake

The sound, when it fell, was loud. Bob Leffler, an ad execu-



tive with offices on North Charles Street, was on the phone with a client when he heard the groaning roar.



Cars, the sidewalk, a fence, a retaining wall and a still-upright streetlight that fell onto the railroad tracks.



View of the collapsed street from St. Paul Street.

"It was like the earthquake," said Leffler, referring to the August 2011 quake that struck the city. "It didn't shake like that, but it was really loud."

No one was injured, according to city officials and Mayor Stephanie Rawlings-Blake, who briefed reporters at the scene.

The collapse came on the second day of a pounding storm that has dumped over four inches of rain in the Baltimore region, causing widespread flooding.

### "Slumping" for Months

As a precautionary measure, city officials evacuated houses on the north side of 26<sup>th</sup> Street. Residents gathered on the street this evening.

Several told *The Brew* they had noticed the street pavement cracking and slumping for months. Leffler said there were other signs the retaining wall was not stable.

Recently, he said, that he noticed, a "dip" in the street near the retaining wall, while the sidewalk abutting the wall seemed to be buckling upward.

Truelove said she has been worried about the slumping street for even longer and suspected "it might go" because the street had collapsed once before, in the 1980s, on the other side of Margaret Brent Elementary School.

"I have refused to park my car on that side for the past two years because I was worried it was going to collapse," she said.

Asked about reports that people have complained repeatedly to the city about problems with the street, Rawlings-Blake said she had "no information" about the reports and would be looking into them.

Complaints about the rail line on 26th Street date back decades, with residents complaining in a 1998 *Baltimore Sun* article that the wrought-iron fencing and walls around the rail right-of-way had been eroding for 15 years, "leaving gaping holes in the residents' protection from a 30 foot drop onto the CSX train tracks."

"I'm just sick of the condition of railroad properties in our city," then-Councilman Bernard C. "Jack" Young is quoted as saying. "Overpasses are falling in."

The stone retaining walls were a relic of the 1890s construction of the B&O's "Royal Blue" line to New York that ran under Howard Street and then turned east along 26th Street along a right-of-way about 25-30 feet below street level.

The large open space on 26th Street between Charles and St. Paul streets was originally planned for a small passenger station.

The station was never built; instead, the railroad decided to build a central station in a then more populated area on Mt. Royal Avenue. Passenger rail service between Baltimore and New York ended in the late 1950s.

The single-track line now sees about 20 freight trains a day as the main route north for CSX.

The railroad suspended service immediately and dispatched crews for what might be several days, or more, of cleanup.

(Fern Shen and Mark Reutter / Baltimore Brew, April 30, 2014,  
<https://www.baltimorebrew.com/2014/04/30/railroad-retaining-wall-collapses-in-charles-village>)

### **Massive street collapse sweeps away cars, covers CSX tracks in North Baltimore (Video)**



The sidewalk along 26th Street caves in just before the cars, sidewalk and retaining wall, seen at far left, collapse into the ravine.

(Kevin Litten and Ryan McDonald / Baltimore Business Journal, Apr 30, 2014,  
<http://www.bizjournals.com/baltimore/news/2014/04/30/massive-sinkhole-sweeps-away-cars-covers-csx.html>)



# ΕΝΔΙΑΦΕΡΟΝΤΑ - ΣΕΙΣΜΟΙ

## California tests natural disaster early warning system



The system was used to forecast flash floods in California

### An early warning system for earthquakes, tsunamis and floods is being trialled in the US.

Scientists are using GPS technology and other sensors to detect the impending threat of natural disasters.

The network is installed in Southern California and has already helped scientists to alert emergency services to the risk of flash floods.

Yehuda Bock from the Scripps Institute of Oceanography said: "This can help to mitigate threats to public safety."

And added: "It means real-time information can be made available."

### Ground motion

The minutes and even seconds before a natural disaster strikes are crucial.

Early warning systems can help emergency services to prepare and respond more effectively and can provide vital information for the public.

In California, researchers have been testing a prototype network for a range of hazards.

The system builds on existing networks of GPS stations, which use satellite technology to make very precise measurements of any ground movement.

On these, they have installed seismic sensors and other instruments that can track changes in weather conditions.

Dr Bock said: "By combining the data from the GPS with the data from these other sensors, we can measure displacements that occur during an earthquake or another event."

He added that the system could detect the tremors that appear seconds before a large earthquake strikes, and accurately assess its magnitude and whether it is likely to generate a tsunami.

The GPS sensors and the meteorological instruments also help the team to monitor the water vapour in the air.

Dr Angelyn Moore, from Nasa's Jet Propulsion Laboratory, said: "It might be surprising that we are using GPS to monitor weather hazards, but GPS is a weather instrument.

"Fundamentally, a GPS station is measuring the time it takes a signal to travel from the GPS satellites to the receiving stations on the ground, and that travel time is modified by the amount of moisture in the air.

"Whenever we measure the position of a GPS station, we are also measuring the amount of water vapour above it."

Through this, the team is able to track in real time how air moisture is changing and whether heavy rain is likely.



GPS stations like this one are fitted with small seismic and meteorological sensors

In the summer, the researchers used the system to forecast rainfall in San Diego.

Traditionally, some of this data comes from weather balloons.

"But there are only two sites at the southern border of California and these are about 150 miles apart. And the weather balloon launches are also infrequent: in San Diego it's only every 12 hours," said Dr Moore.

"In between those many hours between the weather balloon launches, we were able to use the GPS to monitor how the water vapour was changing."

With this real-time information, the team was able to issue flash flood alerts.

Dr Moore added: "This was verified - there were quite a few reports of flooding."

The sensing technology is being combined with communication advances to make sure the information is widely distributed, fast.

Dr Mark Jackson, from the National Oceanic and Atmospheric Administration's National Weather Service, said: "When a forecaster presses that button to issue that warning, it then goes to the police or fire person that's responsible for taking action to protect life and property almost instantaneously.

"We also have the public who now on their smartphones can receive warnings directly that say there is a warning in effect for your area."

The team said the technology was inexpensive, and systems like it could be rolled out around the world.

The findings were presented at the recent American Geophysical Union Fall Meeting in San Francisco.

(Rebecca Morelle / Science reporter, BBC World Service, 2 January 2014, <http://www.bbc.co.uk/news/science-environment-25467873>)

## 'Frost quakes' blamed after Toronto residents wake to loud booming in the night

The extreme cold is leaving Toronto with a bang rather than a whimper as residents around the GTA report loud booming sounds in the night that may be caused by "frost quakes."

People reported noises loud enough to wake them up as temperatures dipped below -20.

The booms occur when moisture in the ground freezes and expands, putting pressure on ice and rock. This pressure is ultimately released with a loud boom and the rock cracks.

According to the Maine Geological Survey, the phenomenon is also known as cryoseisms. The agency calls it "a literal 'cold snap'" and describes the sounds variously as a "deep rumbling" that sent windows shaking, a "shudder" and a cracking sound.

Mike Leibovitz, who lives in Thornhill, said at least four frost quakes hit his house last night, with the strongest one at around 2:30 a.m.

"To be honest, we literally thought that our roof broke or something. Our house pretty much shook," he said.

"It was pretty loud. I mean, the two of us woke up out of deep sleep, it woke my daughter up. It definitely was a boom and my house, my roof was shaking."

Paige Kruger, who lives at Lawrence and Avenue, described similar banging sounds around her house.

"My dad was like walking around the house to see if anyone broke in," she said.

"Then it sounded like somebody was basically banging around in the walls of our house."

Allison Bent, a seismologist with Earthquakes Canada, explained how the "frost quakes" felt similar to earthquakes but were caused by ice.

"What they are is cracking of ice or two blocks of ice moving one against each other. It happens because ice expands when it gets cold," said Bent.

"So it often happens when it's extremely cold, like minus 20 or colder and particularly if there's been a sudden drop in temperature, and especially near lakes and rivers."

It feels a lot like an earthquake to someone close to it, but Earthquake Canada's instruments don't pick up the shaking since these ice quakes are very localized, according to Bent.

"So we suspect that's what's people have been feeling," she said.

As for potential for damage, Bent said she's "never heard of there being any. Usually the effects are very, very localized."

"You can feel the shaking, but as far as I'm aware there's never been any damage from a frost quake," she said, comparing it to a very weak earthquake.

Geoff Coulson, a warning preparedness meteorologist with Environment Canada said that in his 30 years involved in the weather service, he hadn't seen so many reports of frost quakes. He attributed a lot of that to social media.

"In previous years, these things could have been happening, but because they're so localized they may have remained a local story. It didn't really spread to a lot of people to get a sense of, 'Other people heard this too, it wasn't just me hearing things,'" he said.

"We're finding with Twitter and Facebook and things of that nature, groups of people are now realizing that somebody else heard that and suddenly it's getting a lot more attention."

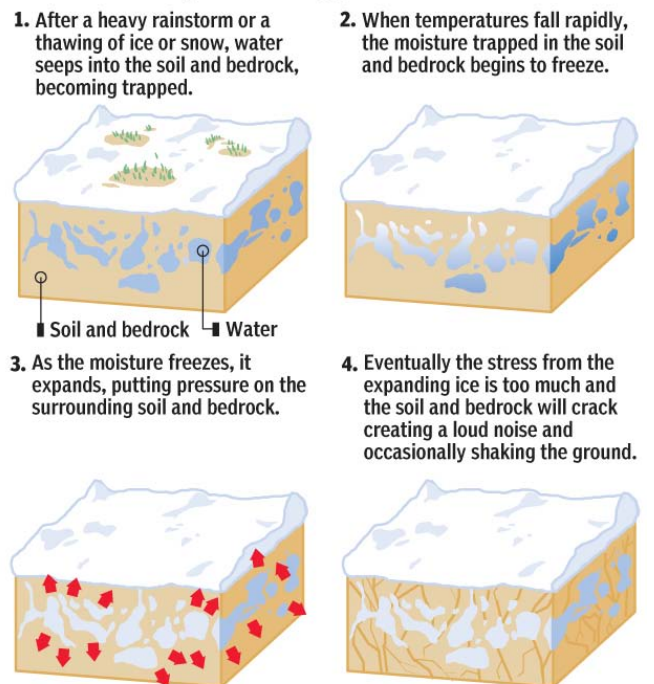
Frost quakes are very rare, and Mr. Coulson said he never heard of them when he was an operational forecaster during the 1998 ice storm that hit eastern Ontario and Quebec. They may have happened, but reports were not widespread — and most people don't know what they are.

Frost quakes have been previously reported in upstate New York, Vermont, Massachusetts, Connecticut and Maine.

(Inayat Singh / National Post, January 3, 2014, <http://news.nationalpost.com/2014/01/03/a-literal-cold-snap-frost-quakes-blamed-after-toronto-residents-wake-to-loud-booming-in-the-night>)

## WHAT IS A FROST QUAKE?

*Frost quakes, also known as cryoseisms, are non-tectonic events brought on by winter weather. They are usually identified by a loud noise in the night with no apparent cause.*



SOURCE: THEWEATHERNETWORK.COM, MACLEAN'S

ANDREW BARR / NATIONAL POST

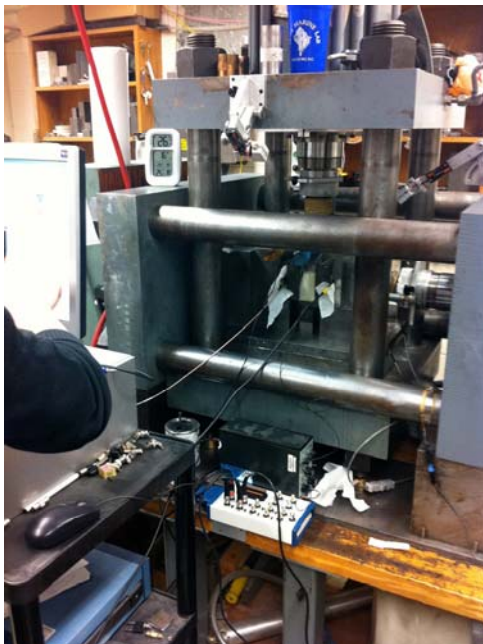
## Faults May Emit Earthquake Warning Signs

There are tantalizing hints some faults issue warning signals in the days and months before a big earthquake, according to new research.

A study of squeaky glass beads squeezed between powerful pistons offers one explanation for how these earthquake warning signals form. The findings were published online Nov. 4 in the journal Geophysical Research Letters.



The signals range from tiny shocks along the fault, which may be beyond the limit of detection by today's seismic monitors, to earthquakes large enough to rattle houses. The common thread is that the final rip — the main earthquake — strikes at or near the site of the smaller, earlier breaks.



A laboratory setup that measured earthquake precursors — warning signs of coming earthquakes.

"They are associated with small failures along the fault patch that is going to fail catastrophically," said Paul Johnson, a geophysicist at Los Alamos National Laboratory in New Mexico and lead study author.

Making a link between these earthquake precursors and the "big one" is controversial in the world of earthquake research. While many laboratory studies indicate there are seismic warning signals to watch for, in the real world, not all earthquakes have foreshocks, as these preliminary shakers are known. Still, geoscientists hope that by better understanding what happens before an earthquake, they may one day have a means of warning the public of increased earthquake risk.

"I think we're seeing the beginning of something potentially really exciting for characterizing an area of increased hazard," Johnson said. "We're not going to predict when an event takes place. [But] this kind of observation can be tested to see whether or not this information will be useful for earthquake hazard and predicting intervals of increased seismic risk." (σ.σ. δες άρθρο στη συνέχεια 13 Crazy Earthquake Facts).

#### Quake lab

In the study, Johnson and his collaborators built a laboratory model that mimics an earthquake fault. The squeaky beads represent gouge, the crushed, ripped-up clay and rock that lines faults. Pressing the beads between two plates imitates the forces that cause earthquakes.

The researchers discovered that the beads start squeaking not long before the laboratory earthquake hits. These "acoustic emissions" are equivalent to small earthquakes on real-world faults, Johnson said.

The study adds to growing evidence that a dense network of quake monitors called seismometers could detect these signals (σ.σ. δες άρθρο στη συνέχεια Earthquake Forecast-

ers Look Closer at Rock Friction) and warn of the increased hazard, Johnson said.

"Most precursors are very small, so if you don't have instruments on the fault or very near the fault, then you're just not going to see them," he said. "These are very small compared to the actual earthquakes."

#### Controversial concept

But many researchers think the laboratory models that suggest earthquake warnings exist don't translate into real-world alerts (<http://www.livescience.com/42200-gps-earthquake-forecasting-costa-rica.html>).

Unlike a lab model, faults in the Earth are filled with fluids, heated to high temperatures, and undergo complex stresses, said Justin Rubinstein, a research geophysicist with the U.S. Geological Survey in Menlo Park, Calif. "It's a dangerous leap to try and take what we see in the lab and say it should happen in real life," Rubinstein said. "Right now, I don't think there's a convincing case that can be made. Sometimes, you get a foreshock sequence, and sometimes you don't."

But Rubinstein also thinks such models are worth careful exploration. "If there are precursors, it would be valuable for us to understand, because obviously, it would be fantastic if we could predict earthquakes," he said.

(Becky Oskin, Staff Writer / Live Science, January 10, 2014, <http://www.livescience.com/42495-model-suggests-earthquake-warning-signs.html>).

### 13 Crazy Earthquake Facts

**1. Earth has been more seismologically active** in the past 15 years or so, says Stephen S. Gao, a geophysicist at Missouri University of Science & Technology. Not all seismologist agree, however (<http://www.livescience.com/10642-chile-earthquake-mother-nature-control.html>).

**2. San Francisco is moving toward Los Angeles** at the rate of about 2 inches per year — the same pace as the growth of your fingernails — as the two sides of the San Andreas fault slip past one another. The cities will meet in several million years. However, this north-south movement also means that despite fears, California won't fall into the sea.

**3. March is not earthquake month**, despite what some people believe. True, on March 28, 1964, Prince William Sound, Alaska, experienced a 9.2 magnitude event — one of the biggest ever. It killed 125 people and caused \$311 million in property damages. And on March 9, 1957, the Andreanof Islands, Alaska, felt a 9.1 temblor. But the next three big-gest U.S. earthquakes occurred in February, November, and December. The devastating major earthquake in Chile of 2010 struck on Feb. 27. And the huge 9.3 temblor that spawned the devastating Indian Ocean tsunami in 2004 occurred on Dec. 26 (<http://www.livescience.com/6887-march-earthquake-month-shaky-facts.html>).

**4. There are about 500,000 earthquakes a year** around the world, as detected by sensitive instruments. About 100,000 of those can be felt, and 100 or so cause damage each year. Each year the southern California area alone experiences about 10,000 earthquakes, most of them not felt by people.

**5. The sun and moon cause tremors.** It's long been known that they create tides in the planet's crust, very minor versions of ocean tides. Now researchers say the tug of

the sun and moon on the San Andreas Fault stimulates tremors deep underground.

**6. A city in Chile moved 10 feet** in the massive 8.8 magnitude earthquake Feb. 27, 2010. The rip in Earth's crust shifted the city of Concepción that much to the west. The quake is also thought to have changed the planet's rotation slightly and shortened Earth's day (<http://www.space.com/7988-chile-earthquake-shortened-days-earth.html>).

**7. There's no such thing as "earthquake weather."** Statistically, there is an equal distribution of earthquakes in cold weather, hot weather, rainy weather, and so on, according to the U.S. Geological Survey. Scientists say there is no physical way that weather could affect the forces several miles beneath the surface of the earth where quakes originate. The changes in barometric pressure in the atmosphere are very small compared to the forces in the crust, and the effect of the barometric pressure does not reach beneath the soil.

**8. Earth's bulge was trimmed** a little by the 2004 Indonesian earthquake, the 9.0+ temblor that generated the deadly tsunami on Dec. 26 that year. Earth's midsection bulges in relation to the measurement from pole-to-pole, and the catastrophic land displacement caused a small reduction in the bulge, making the planet more round.

**9. The Pacific Ring of Fire** is the most geologically active region of Earth. It circles the Pacific Ocean, touching the coasts North and South America, Japan, China and Russia. It's where the majority of Earth's major quakes occur as major plate boundaries collide (<http://www.livescience.com/6139-earth-earthquake-hotspots.html>).

**10. Oil extraction can cause minor earthquakes.** These are not the quakes you read about. Rather, because oil generally is found in soft and squishy sediment, when oil is removed other rock moves in to fill the void, creating "mini-seismic events" that are not noticeable to humans.

**11. The largest earthquake ever recorded** was a magnitude 9.5 in Chile on May 22, 1960.

**12. Quakes on one side of Earth** can shake the other side. Seismologists studying the massive 2004 earthquake that triggered killer tsunamis throughout the Indian Ocean found that the quake had weakened at least a portion of California's famed San Andreas Fault. The Chilean quake of 1960 shook the entire Earth for many days, a phenomenon called oscillation that was measured by seismic stations around the planet (<http://www.livescience.com/9710-big-quakes-weaken-faults-side-earth.html>).

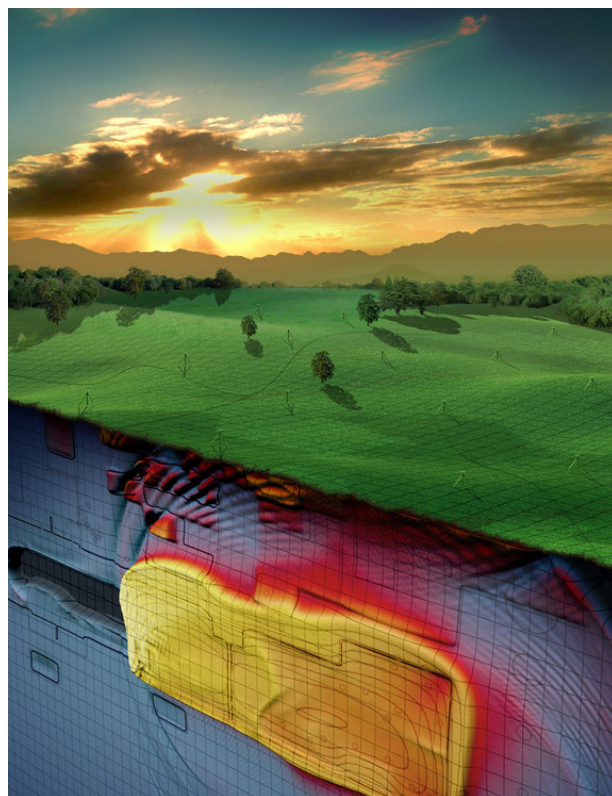
**13. The deadliest earthquake ever** struck January 23, 1556 in Shansi, China. Some 830,000 are estimated to have died (<http://www.livescience.com/6932-deadliest-earthquakes-history.html>).

(LiveScience Staff / March 09, 2010, <http://www.livescience.com/6187-13-crazy-earthquake-facts.html>)

### Earthquake Forecasters Look Closer at Rock Friction

More-accurate forecasts of earthquakes may arise from a new computer model focusing on the physics of the rock in one quake-prone segment of the San Andreas fault, researchers say.

Although the basic physics of earthquakes have been known for a century, developing computer models of earthquake dynamics has been challenging. However, the amount of historical data available from the Parkfield segment of the San Andreas fault may prove helpful.



Schematic view of an on-going seismic rupture on the Parkfield segment of the San Andreas Fault.

"A major limitation to earthquake prediction is that we do not as of today know the physics that explains the full spectrum of fault behavior," said researcher Sylvain Barbot, a geophysicist at the California Institute of Technology. "The difficulty of earthquake prediction is that they [quakes] occur during just a few seconds but repeat every hundreds of years, and that the details of what happened during these few seconds carry a lot of weight in how long it will take before the next one."

Researchers are now attempting to figure out what happens during those few seconds by analyzing the friction of rock. Their findings are detailed in the May 11 issue of the journal Science.

### Fault friction

The likelihood of a quake is dictated by the physics of the friction between rocks and the forces exerted on them, similar to how rubbing your hands with and without gloves on requires different amounts of effort.

Barbot and his colleagues applied their rock physics strategy on the Parkfield area, some 200 miles (320 kilometers) northwest of Los Angeles. It has experienced a relatively predictable cycle of earthquakes for the past 150 years, seeing moderate-magnitude earthquakes every 20 years on average. That pattern led to the only official earthquake forecast in the United States: In 1985, scientists predicted that a magnitude 6 earthquake was likely to occur there before 1993. A magnitude 6 quake did occur there, but not until September 2004. The exact timing of quakes at Parkfield continues to elude researchers.

Taking advantage of Parkfield's history of detailed measurements, the scientists constructed a physics-based model of the region.

"What's great about these earthquakes is that they don't kill anyone, and we can study them with the best available technology every time they happen," Barbot said. "If there is one place in the world where we could predict earthquakes, it would be at Parkfield."

Their model could explain the distribution of small earthquakes at Parkfield and how they related to the occurrence of large earthquakes.

"We can take physical laws describing how fault rocks behave in the lab and create models that reproduce a whole range of observations in a natural setting," Barbot told OurAmazingPlanet. "This implies that we are getting closer to understanding how earthquakes really work."

### Not a prediction

Barbot said it would be dangerous to conclude from the researchers' results "that we may seem ready to predict earthquakes." Instead, this model "can readily be used to identify the area of the fault that needs to be better monitored to capture earthquake precursors (<http://www.livescience.com/17301-ozone-gas-earthquake-precursor-warning.html>), and test if they exist at all," he said.

This model could thus over time lay the groundwork for earthquake prediction. "Even if we're not ready for a full physics-based earthquake forecast, we're setting up the tools for this kind of analysis," Barbot said.

In the future, this strategy could analyze other faults as well. "In general, such models will be the most accurate in areas where we have a long and detailed history of past earthquakes, knowledge of the precise geometry of the fault at depth, and an idea of the spatial distribution of the friction on the plate interface," Barbot said.

A long-term goal of the researchers "is to integrate and study the interaction among neighboring faults or fault segments," Barbot said. "The Cholame segment of the San Andreas fault, in the Carrizo Plain, hosted a magnitude 7.9 earthquake in 1857, and there is a possibility that the Parkfield earthquakes, immediately to the north, may trigger an event of similar size."

(Charles Q. Choi, OurAmazingPlanet Contributor / Live Science, May 10, 2012, <http://www.livescience.com/31418-earthquake-forecasts-friction.html>)



### Injection wells seen as possible cause of earthquakes

The small earthquakes that shook the Azle area late last year have put a spotlight on another aspect of the oil and gas drilling boom in North Texas — injection wells that get rid of millions of gallons of water used and polluted in the process.

The state has about 35,000 active injection wells, according to the Texas Railroad Commission. Crude oil wells typically produce tons of salt water along with oil, and injection wells pump that water back down into the formation to help ex-

tract more oil. Injecting water into a depleting formation is rarely the cause of a seismic event, experts say.

But about 7,000 of the state's injection wells are being used for disposal. The widespread use of hydraulic fracturing to extract natural gas and oil from shale formations has increased the need for disposal wells, which are used to send wastewater deep underground.

And there's some evidence that they can cause the Earth to quiver.

"In a way, Texas has been a vast experiment in injection wells," some of which are used to dispose of oil field waste, said seismologist Cliff Frohlich, associate director of the Institute for Geophysics at the University of Texas at Austin.

Millions of gallons of water are typically used to fracture, or frack, a well, and much of it eventually returns to the surface. Some is recycled, but most is pumped down disposal wells. And the extra fluid can migrate far from the well.

Disposal wells usually don't produce seismic events, but sometimes they do, said Frohlich, who has studied the link between energy production and earthquakes. In a 2012 study, Frohlich found that "injection-triggered earthquakes are more common than is generally recognized."

There are five active disposal wells in northern Parker County and southern Wise County, the site of more than 20 quakes that shook the Azle area in November and December. Those events prompted the Texas Railroad Commission to hold a public meeting in Azle on Jan. 2.

After hearing a litany of complaints about disruption and property damage from residents who packed the hearing at Azle High School, the three-member Railroad Commission, which regulates oil and gas production, voted to hire an in-house seismologist.

But some answers could be forthcoming even before that position is filled.

Researchers from Southern Methodist University and the U.S. Geological Survey have installed a network of seismic monitors around Azle and Reno, in northern Parker County, with the goal of collecting better data on the quakes.

Art McGarr, an earthquake researcher at the Geological Survey who is working on the Azle project, said Thursday that researchers expect to present their findings in late April. But they could come to a determination earlier than that and don't necessarily need additional quakes to occur to do their job.

"We already have a lot of data in hand" from previous quakes, McGarr said. "We're chewing through it."

### The wild card

Faults, or breaks in the Earth that typically formed millions of years ago in underground strata, are the big unknown that can influence whether an injection well might cause an earthquake. Faults aren't always known before drilling takes place, and even if they were, McGarr said, it's not certain that they will produce an earthquake if an injection well is drilled nearby.

Still, as Ken Morgan, director of the TCU Energy Institute, put it: "There are better places and worse places for disposal wells. That is common sense. If you have faults and a cluster of quakes, you've rounded up some suspects" by looking at nearby injection wells.

McGarr, Morgan and Frohlich said it can be hard to identify a single injection well as the cause of a particular quake.



But a swarm of seismic events like the Azle quakes is certainly grounds for suspicion.

"Evidence would be if earthquakes started not too long after an injection well began operation," McGarr said. "If they started within one or two months, that's pretty good evidence. Even better evidence is if injection is stopped and the earthquakes stop."

Scientists have actually controlled earthquakes by starting and stopping underground fluid injection. In what Morgan said is still the gold standard of such studies, researchers at the Rocky Mountain Arsenal near Denver in 1966 produced earthquakes by beginning or increasing injection. The quakes stopped when injections ceased.

In 1962, the well started disposing of wastewater from chemical weapons production. By 1966, more than 700 quakes had occurred within 5 miles of the well.

Disposal wells can also produce seismic events after years of operation. McGarr's research shows that the total volume of fluid injected in a well can be the biggest factor in triggering quakes, not how fast it is injected.

### **Narrowing the field**

The five disposal wells around Azle went into operation between 2005 and 2009, according to Railroad Commission data. Three are permitted to inject up to 25,000 barrels a day (or 1.05 million gallons, at 42 gallons per barrel). One well is limited to 15,000 barrels and another to 10,000 barrels. All are injecting considerably less than their allowed maximums at depths of 9,000 to 11,000 feet.

According to filings with the Railroad Commission, the largest well, operated by Foxborough Energy Co. of Oklahoma City, injected nearly 3.4 million barrels, or 142 million gallons, in the first nine months of 2013, the latest data available. The smallest, run by Strata Operating, injected 618,000 barrels, or nearly 26 million gallons, in the same nine months.

The additional seismic monitors that SMU is installing will allow researchers to locate new earthquakes much more accurately, researchers said. Earthquakes are tagged two ways: the focus, which is the depth underground where the quake originated, and the epicenter, which is its position on the surface.

Frohlich said all of Texas has about a dozen active seismic monitors at any time. That limits the accuracy of the epicenter to several miles. And Morgan said the estimated depth can be as broad as one of three ranges: shallow, moderate or deep.

McGarr said that with half a dozen monitors in just the Azle area, researchers can pinpoint the epicenter to within 200 to 300 meters and the depth to within about 500 meters.

### **Red light, green light**

Fort Worth lawyer Jim Bradbury, who has followed the environmental issues of energy production, said state regulators should adopt a standard proposed by the U.S. Geological Survey called the traffic light system.

If earthquakes above a certain level occur near a disposal well, it could get a yellow light, requiring a reduction in the amount it's injecting. "If seismicity continued or escalated, operations could be suspended" — the red light, the agency says.

The Railroad Commission has inspected all of the wells in the Azle area over the last two months, including three last week, according to reports emailed to the *Star-Telegram*.

"When earthquakes are reported, our staff will determine if saltwater disposal wells are nearby and then inspect the facilities to ensure that they are in compliance with their Railroad Commission permit conditions," said spokeswoman Ramona Nye.

(Jim Fuquay / Star-Telegram, Saturday, Jan. 11, 2014, <http://www.star-telegram.com/2014/01/10/5476064/injection-wells-seen-as-possible.html?rh=1>, <http://www.star-telegram.com/2014/01/10/5476064/injection-wells-seen-as-possible.html?rh=1#storylink=cpy>)



### **L.A. Mayor Garcetti calls for aggressive earthquake safety effort**

Los Angeles Mayor Eric Garcetti on Tuesday announced an aggressive new plan to tackle earthquake safety, including how to better protect vulnerable buildings.

Marking the 20th anniversary of the destructive Northridge earthquake, Garcetti said Los Angeles would for the first time partner with the U.S. Geological Survey to build a comprehensive strategy for dealing with how to better protect private buildings and other resources such as telecommunications and the water supply during a major temblor.



#### **Bullock's**

The dangers of brittle concrete buildings were underscored by the collapse of the Bullock's department store at Northridge Fashion Center in the 1994 Northridge earthquake.

The store was built in 1971, before more robust building codes were enacted. Hundreds of people could have died, but the earthquake hit at 4:31 a.m., when the store was closed. (Steve Dykes / Los Angeles Times / January 17, 1994)

The move comes as the City Council is considering several seismic safety initiatives, including investigating potential dangerous concrete and soft-first-story buildings.

Taken together, the moves mark the most significant effort to improve earthquake safety in Los Angeles in a generation.



### **Barrington Building**

The six-story concrete Barrington Building -- home to prominent dentists and psychiatrists to the stars -- suffered severe damage to its columns in the 1994 Northridge quake. That damage can be seen in the X-shaped cracks, precursors to a collapse. The city called the building at 11665 Olympic Blvd. an "immediate hazard" and ordered its demolition. (Jonathan Alcorn / For The Times / January 21, 1994)

"What's really at stake is the viability of this city," said U.S. Geological Survey seismologist Lucy Jones, who will spend a year meeting with stakeholders and experts and devising policy recommendations for the city of Los Angeles.



### **Olive View Medical Center**

The concrete Olive View Medical Center in Sylmar suffered major damage in the 1971 Sylmar earthquake. Three concrete stair towers broke free from the main hospital and toppled to the ground. Three people died. (Los Angeles Times / October 16, 2013)

### **FULL COVERAGE: California earthquakes**

"We are here to make sure we are ready when, not if, the next earthquake hits," Garcetti said at a news conference Tuesday.

The U.S. Geological Survey will essentially loan out Jones this year to convene public meetings, talk with property owners, and consult with technical experts about how to comprehensively deal with a persistent, unresolved problem

-- how to get privately owned buildings seismically strengthened in Los Angeles.



### **Olive View Medical Center**

Concrete columns supporting the stairwells of Olive View Medical Center failed because there was too little steel reinforcement. After the 1971 Sylmar earthquake, county officials toured the destruction. (John Malmin / March 4, 1971)

Jones said her assignment for 2014 will bridge earthquake science and public policy to reduce earthquake risk.

"We are donating the majority of my time this year to working together and trying to find solutions to problems," Jones said. "It's a good prototype of taking our science and getting it applied to actually making a difference."



### **San Fernando Veterans Administration Hospital**

San Fernando Veterans Administration Hospital patients wait for evacuation to other facilities as the ruins of collapsed buildings are searched for victims after a magnitude 6.6 earthquake hit near Sylmar on Feb. 9, 1971. Two hospitals and two major freeway interchanges were destroyed, 64 people were killed and the lower dam at the Van Norman Reservoir almost failed. (Bruce Cox / Los Angeles Times / October 16, 2013)

Garcetti made the announcement a few days before the 20<sup>th</sup> anniversary of the 1994 Northridge earthquake, which killed about 60 people. He said it is essential for the city to make progress on earthquake safety.

While Northridge was damaging, Garcetti said, "The Big One could be a lot worse. ... Too many in our city have stopped thinking about how we can best prepare."





#### **Veterans Administration Hospital**

Two concrete buildings at the San Fernando Veterans Administration Hospital crumbled in the 1971 Sylmar earthquake, killing 49 people. (Bruce Cox / Los Angeles Times /February 9, 1971)



#### **Veterans Hospital**

Two three-story buildings collapsed at the San Fernando Veterans Administration Hospital, crushing many patients inside. The last body was pulled out of the rubble four days after the Sylmar earthquake. (February 8, 1971)



#### **Veterans Administration Hospital**

Another view of one of the two concrete buildings at the Veterans Administration Hospital that collapsed in the 1971 Sylmar earthquake. (Ben Olender /February 9, 1971)



#### **Veterans Administration Hospital aerial**

An aerial view of the San Fernando Veterans Administration Hospital after the 1971 Sylmar earthquake. (Larry Sharkey / Los Angeles Times /February 8, 1971)



#### **Pyne Gould Corp. building**

The concrete Pyne Gould Corp. building collapsed in the 2011 Christchurch earthquake in New Zealand. Eighteen people died. (Canterbury Earthquakes Royal Commission Final Report /October 16, 2013)



#### **Pyne Gould Corp. building**

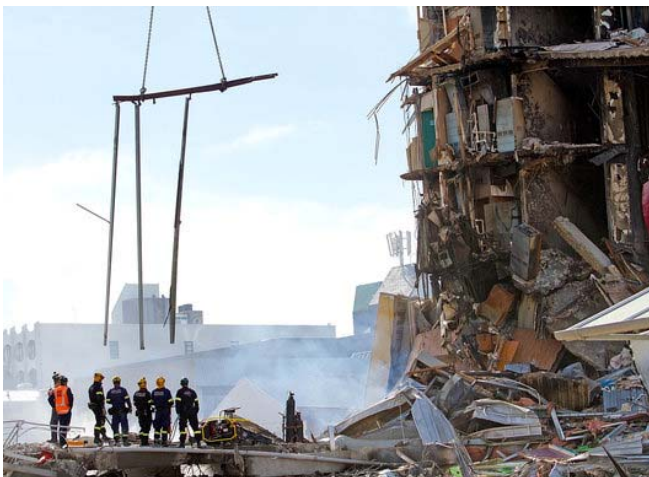
The Pyne Gould Corp. building collapsed when the magnitude 6.3 earthquake struck Christchurch, New Zealand. It was built in the 1960s, before the adoption of modern seismic standards for concrete buildings. (Hannah Johnston / Getty Images /February 23, 2011)





#### CTV building

The six-story concrete CTV building in Christchurch, New Zealand, collapsed in the 2011 earthquake, killing 115 people. (Canterbury Earthquakes Royal Commission Final Report /October 16, 2013)



#### CTV building

The CTV building housed a television station, a medical clinic and English-language classrooms. One woman, Mary Amantillo, 23, sent text messages to her mother after the earthquake. "Ma, I got buried," she wrote. Forty minutes later, she texted, "Ma, I can't move my right hand." She died with her friend Valquin Bensurto. (Marty Melville /February 24, 2011)

Garcetti said he is particularly interested in the concerns of property owners "as we discuss how to retrofit privately owned buildings."

Garcetti laid out a timeline for the year's goals, starting with developing in the first two months a list of problems and consequences. By spring, Jones will seek input from relevant stakeholders as well as input from technical experts. Later in the year, public hearings will be held and recommendations will be due to the mayor by December.

Jones will continue to be paid by the U.S. Geological Survey.

The partnership with the city and USGS also follows a [Times report](#) on concrete buildings that were built before 1976. By the most conservative estimate, as many as 50 of the more than 1,000 old concrete buildings in the city would collapse in a major earthquake, exposing thousands to injury or death.

Concrete buildings may look strong, but many older concrete buildings are vulnerable to the sideways movement of a major earthquake because they don't have enough steel reinforcement to hold columns in place. Experts say sorting out which present the greatest danger of injury and death to occupants is a daunting problem that will require building-by-building assessments by structural engineers.

The Times has also written several stories exploring development on or near fault lines. A recent [investigation](#) found that Los Angeles and Santa Monica approved more than a dozen construction projects on or near two well-known earthquake faults without requiring seismic studies to determine if the buildings could be destroyed in an earthquake.

Wooden soft-story structures often are built over carports and held up with slender columns, leaving the upper floors at risk of crashing into ground-floor apartments during shaking. The 1994 Northridge earthquake damaged or destroyed about 200 of these structures, and 16 people died in the Northridge Meadows apartment complex.

Later Tuesday, the City Council is scheduled to commemorate the 20th anniversary of the Northridge earthquake and discuss eight motions related to seismic safety.

(Rong-Gong Lin II and Rosanna Xia / Los Angeles Times, January 14, 2014, <http://www.latimes.com/local/lanow/la-me-ln-earthquake-safety-los-angeles-20140114,0,7496398.story#axzz2qZFz4JcT>, <http://www.latimes.com/local/lanow/la-me-ln-earthquake-safety-los-angeles-20140114,0,7496398.story#ixzz2qkIRHTuQ>)



### Researchers Use Ocean Waves To Forecast Seismic Shaking

**New research at Stanford University has capitalized upon the ambient seismic field—created by ocean waves as they strike the earth's crust—to forecast potential earthquakes in the Los Angeles basin.**

The city of Los Angeles is all too familiar with earthquakes. Although minor earthquakes are a near daily occurrence in Southern California, the last major earthquake in the region, in 1994, was devastating. The Northridge earthquake measured a magnitude 6.7, killing 60 people and injuring 7,000, collapsing infrastructure, and damaging more than 40,000 buildings in the Los Angeles area. Preparing the city for the next major earthquake before it arrives is thus of critical importance to the city.

So research conducted by Stanford University that has resulted in a new method of forecasting the potential ground motion in the region before a major seismic event is making news. The method capitalizes on the ambient seismic field created by ocean waves as they hit the earth's crust, and was used to validate, for the first time, the ground mo-

tion simulations conducted by the Southern California Earthquake Center in [2006](#) and the U.S. Geological Survey (USGS) in [2008](#). The “virtual earthquakes” created by the Stanford study confirm the computer models’ projections that greater shaking would be experienced in the sedimentary basin of Los Angeles than in other nearby areas.



*The Northridge earthquake in 1994 killed 72 people and damaged elevated roadways, bridges, and residential and commercial structures. New research suggests that the background seismic fields created by ocean waves hitting the earth’s crust can help seismologists predict the nature and impact of future earthquakes in the Los Angeles region.*  
FEMA News Photo/Robert A. Eplett

The approach was conceptualized by Greg Beroza, Ph.D., a professor of earth sciences in Stanford University’s department of geophysics and the deputy director of the Southern California Earthquake Center (SCEC), and implemented by Marine Denolle, Ph.D., currently a postdoctoral scholar at Scripps Institution of Oceanography at the University of California, San Diego, who conceptualized and implemented the field work as part of her doctoral work at Stanford. Both Beroza and Denolle wrote in response to written questions posed by *Civil Engineering* online.

Denolle’s work was also overseen by Eric Dunham, Ph.D., an assistant professor of geophysics at Stanford, and Germán A. Prieto, Ph.D., an assistant professor of geophysics at the Massachusetts Institute of Technology.

The ocean waves the team studied create small pressure pulses that are constantly picked up by seismometers. By measuring the time it takes these pulses to move between sensors, the underlying soil conditions and their response to ground motion can be mapped. Denolle’s examination of the Los Angeles basin represents the first time that these pulses have been used to forecast potential ground motion during earthquakes. She placed temporary sensors along the San Andreas Fault at a depth of 1 to 2 ft and coupled them with existing sensors to track the movement of the pulses as they moved from the fault through the basin. Denolle then processed the signals and “developed corrections for depth, sense of slip in the earthquake, and finiteness of the fault,” Beroza explained.

The research produced an effective new approach for measuring, understanding, and anticipating the effects of geology on seismic waves: “Rather than waiting passively for an earthquake to occur that will test our predictions, we can move actively to deploy instruments in areas of concern to learn what we want to know before an earthquake happens,” Beroza said.

Robert Graves, Ph.D., the Southern California coordinator for the USGS’s Earthquake Hazards Program, sees the potential of the method to work alongside computer simulations. In written responses to questions posed by *Civil Engineering* online, Graves said, “The benefit of this new ap-

proach is that it maps out the potential ground shaking levels for future earthquakes using information based solely on existing ground motion observations.” Computer simulations, on the other hand, can be “incomplete or uncertain in various regions, and thus the predictions of ground shaking based on the simulations also will have uncertainties,” Graves said.

Using the ambient seismic field to map potential ground motion “potentially reduces the level of uncertainty with the ground motion predictions,” Graves said. However, both computer simulation and virtual earthquake analysis, as was done by Denolle, are both needed. “I view the virtual earthquake approach and the simulation approach as being complementary approaches to the ground motion prediction problem,” Graves said.

This proof-of-concept study is just the first step, and was limited to long-period seismic waves because the temporary sensors were placed for short periods of time just below the ground’s surface, Denolle pointed out. “Only tall buildings, and large infrastructures (bridges, for instance), are sensitive to those frequencies,” she said.

Still, the practical implications of Denolle’s findings are immediate. Los Angeles Mayor Eric Garcetti recently announced that the city was partnering with the USGS to develop earthquake resilience strategies for the city. As part of this partnership, Lucile Jones, Ph.D., a seismologist with the USGS, will be working as the science advisor to the mayor for seismic safety. She will spend the coming 12 months applying the lessons learned from the region’s annual earthquake preparedness drills, called [ShakeOuts](#), to develop recommendations for reducing seismic risks in the Los Angeles region, focusing particularly on four major areas: communications systems, water infrastructure, non-ductile reinforced concrete buildings, and buildings with “soft” first stories.

California’s “crust is young and hot and broken up with faults, so it’s a poor transmitter of energy,” says Jones. As a result, ground motion “dies off really quite quickly, but then when you have these local soil conditions it can amplify the shaking,” she says. As waves travel through the ground, Jones explains, certain ground conditions—such as the chain of sedimentary basins that connect the Los Angeles basin to the San Andreas Fault—can act as an “energy channel,” focusing the energy in a certain direction. Before this study, the theory was that the band of thick sediments in front of the San Gabriel Mountains would act as a wave guide, directing seismic waves to the Los Angeles basin, where they would bounce back and forth within the basin for a longer period of time than what is experienced at the epicenter. This new study has confirmed that the ground motion behaves in precisely that manner.

The research conducted at Stanford “really changes the answer of what the maximum credible earthquake shaking will be [within the basin],” Jones says. “Especially in the long-period motion, which will impact the big buildings.” The study confirms that previous computer modeling of Los Angeles’s ground motion, which was criticized as showing too much motion, “is the appropriate one to work from,” she notes. “So it’s great to have, especially at the beginning of the project.”

Structural engineers are tasked with designing the strongest buildings possible while being conscious of their client’s budgets, Jones points out, so knowing the potential ground conditions during a maximum credible earthquake is crucial, determining the seismic strength required of a building.

Which is why the existence of a “wave guide” in the Los Angeles basin is of such paramount importance, Jones says. “If we said, ‘Okay, it’s only going to be the smallest shaking



that you'd expect from an ordinary location,' and that's how you build the building, and then we get these extra strong motions, [because the] wave guide causes specific amplification, you're talking about the potential collapse of high-rises," Jones says. "Especially because the biggest issue is these really long-period ground motions that are strongly affecting the tallest buildings."

Measuring shorter wave frequencies, which affect smaller buildings, using the ambient seismic field is also possible, but the sensors would need to be deployed for longer than 5 months, Denolle said. Additionally, high-quality instruments will need to be deployed in vault-like environments and attached to concrete bases to ensure their ability to measure small ground motions. "We would need borehole instruments: [such as] when people drill through the ground, maybe 100 meters down, to deploy similar instruments, much like the Japan High Sensitivity Seismograph Network," Denolle said.

The usefulness of ambient noise mapping and virtual earthquake forecasting is not limited to sedimentary basins. "It is worth mapping anywhere people are affected, or anywhere the knowledge we would learn from that area would be useful to our global understanding," Denolle said. "Sedimentary basins exacerbate the strength of the shaking, but being close to a fault stays a first order effect. Anywhere with rockier areas would also work."

Denolle is currently working with colleagues in Tokyo to similarly map potential earthquake ground motions in Japan. "The Alpine Fault in New Zealand could be the next target as [the city of] Christchurch also sits on a sedimentary basin and could feel the large Alpine Fault future earthquake," Denolle said. "[The] possibilities are endless."

The findings from the study were first published in the January 14, 2014 issue of Science.

(Catherine A. Cardno, Ph.D. / Civil Engineering, ASCE, 11 February 2014, [http://www.asce.org/CEMagazine/Article.aspx?id=23622329512#.Uvp2i2j\\_uLw](http://www.asce.org/CEMagazine/Article.aspx?id=23622329512#.Uvp2i2j_uLw))



### **Το ΕΜΠ συντονιστής σε πρότζεκτ για την ανάπτυξη ενός συστήματος ελέγχου κτιρίων μετά από καταστροφές**

Υποδομές στρατηγικής σημασίας, όπως, κυβερνητικά κτίρια, αεροδρόμια, γέφυρες και κεντρικές εγκαταστάσεις μεγάλων εταιρειών αποτελούν συχνά στόχο τρομοκρατικών ενεργειών. Επίσης, βλάβες σε τέτοιες υποδομές μπορεί να καταγραφούν μετά από φυσικές καταστροφές.

Η διαδικασία της αξιολόγησης βλαβών σε κατασκευές μέχρι σήμερα, όποια και αν είναι η γενεσιουργός αιτία, βασίζεται κυρίως στην επιθεώρηση από εξειδικευμένους μηχανικούς. Οι κατασκευές, εν γένει, μετά από ισχυρές καταπονήσεις φθάνουν ή ξεπερνάνε τα όρια αντοχής ή λειτουργικότητάς τους, εκδηλώνοντας βλάβες που μπορεί να είναι είτε ορατές και εντοπίσιμες, είτε υπαρκτές, αλλά χωρίς να εκδηλωθούν εντονα σημάδια φθοράς στην κατασκευή. Όταν οι βλάβες στις κατασκευές είναι τέτοιου βαθμού που δεν επιτρέπουν ασφαλή συμπεράσματα ως προς την καταπόνηση των κατασκευών, είναι υποχρεωτική η περαιτέρω μελέτη και ανάλυσή τους, με αποτέλεσμα να καθιστάται η πληγείσα κατασκευή μη λειτουργική για μεγάλο χρονικό διάστημα.



Το νέο ευρωπαϊκό ερευνητικό έργο RECONASS ([www.reconass.eu](http://www.reconass.eu)) που ξεκίνησε τις εργασίες του πρόσφατα, στοχεύει στην ανάπτυξη ενός συστήματος ελέγχου για κατασκευές που θα παρέχει μια αξιόπιστη και συνεχή αξιολόγηση της στατικής κατάστασής τους μετά από μια καταστροφή (π.χ. σεισμός, έκρηξη κ.ά).

Η τεχνολογική λύση που αναπτύσσει το έργο αναμένεται να παρέχει άμεσα και συνεχώς ενημερωμένα δεδομένα σχετικά με την κατάσταση της κατασκευής, σε σχέση με την αντοχή και τη λειτουργικότητά της. Το έργο RECONASS (Reconstruction and REcovery Planning: Rapid and Continuously Updated CONstruction Damage, and Related Needs ASSessment) συγχρηματοδοτείται από την Ευρωπαϊκή Ένωση στα πλαίσια του 7ου Προγράμματος Πλαισίου.

Το έργο έχει διάρκεια 3,5 χρόνια (έως το Μάιο του 2017) και υλοποιείται από μία κοινοπραξία 9 εταιριών από 6 ευρωπαϊκές χώρες. Ο συνολικός προϋπολογισμός του έργου είναι 5.479.161 ευρώ, από τα οποία η ευρωπαϊκή χρηματοδότηση ανέρχεται στα 4.260.240 ευρώ. Συντονιστής και τεχνικός διαχειριστής του έργου είναι το Ερευνητικό Πανεπιστημιακό Ινστιτούτο Συστημάτων Επικοινωνιών και Υπολογιστών (ΕΠΙΣΕΥ), με υπεύθυνο τον Δρ. Άγγελο Αρδίτη, Ερευνητή Α' και Διευθυντή της ερευνητικής ομάδας I-SENSE του ΕΠΙΣΕΥ. Η πρώτη συνάντηση της κοινοπραξίας του έργου διοργανώνεται από τον συντονιστή στην Αθήνα, στις 13-14 Φεβρουαρίου 2014.

Το ερευνητικό έργο RECONASS θα επιδιώξει με τη χρήση ενός συστήματος επίβλεψης κτιρίων και εγκαταστάσεων, που αποτελείται από ασύρματους αισθητήρες θέσης, καταπόνησης, επιτάχυνσης και θερμοκρασίας, καθώς και με την επεξεργασία των δεδομένων από λογισμικά που επιτελούν δομική και οικονομική αξιολόγηση, να εκτιμήσει την κατάσταση των υπό επίβλεψη εγκαταστάσεων από στατική άποψη, τη γενική εικόνα των ζημιών, αλλά και να υπογραμμίσει τις ανάγκες σε υλικά, κόστη, ανθρώπινο δυναμικό, για αποκατάσταση της ασφαλούς λειτουργίας τους. Το σύστημα αυτό, που θα υλοποιηθεί και θα δοκιμαστεί στα πλαίσια του έργου, θα επιτρέπει την αποστολή των δεδομένων σε σχεδόν πραγματικό χρόνο και υπό οποιοσδήποτε συνθήκες σε ένα απόμακροσμένο σταθμό, που θα είναι υπεύθυνος για την επεξεργασία τους και τον περαιτέρω συντονισμό των ενεργειών διαχείρισης της κρίσης.

Εκτός από τις δράσεις διάχυσης και προβολής του έργου στο ευρύ κοινό, καθώς και την ανταλλαγή πληροφοριών με άλλα έργα και οργανισμούς στον εν λόγω τομέα, το ΕΠΙΣΕΥ είναι υπεύθυνο επίσης και για τον σχεδιασμό και την υλοποίηση της τηλεπικοινωνιακή λύσης, που θα διασυνδέει το σύστημα ελέγχου και καταγραφής δεδομένων με τον κεντρικό σταθμό επεξεργασίας και οπτικοποίησης. Η λύση αυτή θα περιλαμβάνει καινοτομία στην διαλειτουργικότητα των μέσων αλλά και στους απαιτούμενους πόρους για την υλοποίησή της, παρέχοντας ταυτόχρονα υψηλό επίπεδο αξιοπιστίας.

Η αξιόπιστη και συνεχής καταγραφή βλαβών στις κατασκευές μέσω του συγκεκριμένου συστήματος ελέγχου, σύμφωνα με τους ερευνητές του ΕΠΙΣΕΥ, μπορεί να αποτελέσει

μία αποτελεσματική λύση για την αντιμετώπιση πολλών προβλημάτων και να προσφέρει σημαντικά αποτελέσματα, τόσο για την κοινωνία όσο και για την οικονομία, όπως συν-οψίζονται παρακάτω:

*Οι εργασίες επισκευών σε περίπτωση καταστροφών θα ξεκινούν πολύ νωρίτερα.*

*Τα συνεργεία εκτάκτου ανάγκης θα έχουν στη διάθεσή τους σημαντικές πληροφορίες σχετικά με την κατάσταση των ζημιών σε εγκαταστάσεις.*

*Το κόστος των καταστροφών αναμένεται να μειωθεί, καθώς θα αποφεύγεται έγκαιρα η κατάρρευση επιρρεπών υποδομών, προστατεύοντας έτσι γειτονικές κατασκευές αλλά και διαφυλάττοντας την ασφάλεια των πολιτών σε περιπτώσεις πυκνοκατοικημένων περιοχών.*

*Θα γίνεται πιο γρήγορα γνωστή η ανάγκη κατεδάφισης εγκαταστάσεων.*

*Η γνώση της στατικής κατάστασης των υποδομών θα μειώσει το χρονικό διάστημα που τα κτίρια παραμένουν μη λειτουργικά και ταυτόχρονα τις οικονομικές απώλειες από την παύση των δραστηριοτήτων τους.*

*Θα γίνεται άμεση εκτίμηση της κατάστασης κρίσιμων κρατικών υποδομών (π.χ. νοσοκομεία, υπουργεία, κ.τ.λ.) ούτως ώστε να τίθενται πιο γρήγορα στη διάθεση των αρχών στα πλαίσια αντιμετώπισης κρίσεων.*

*Η χρήση του συστήματος RECONASS θα παρέχει βελτίωση της επιχειρησιακής γνώσης σε περίπτωση καταστροφής.*

(Η ΚΑΘΗΜΕΡΙΝΗ, 17.02.2014, <http://www.kathimerini.gr/754217/article/teknologia/qadqts/to-emp-syntonisths-se-protzekt-gia-thn-anapty3h-enos-systhmatos-elegxoy-ktiriwn-meta-apo-katastrofes>)



### **Ρυτίδες στον Ειρηνικό Θεαματικό animation δείχνει το τσουνάμι της Χιλής να φτάνει στην Αυστραλία**



Τρεις ημέρες μετά το σεισμό των 8,2 βαθμών που ταρακούνησε τη Χιλή την 1η Απριλίου, αμερικανική υπηρεσία παρουσιάζει προσομοίωση που δείχνει την εξάπλωση του τσουνάμι σε ολόκληρο τον Ειρηνικό Ωκεανό.

Το τσουνάμι είχε μικρό ύψος και δεν προκάλεσε θανάτους ή ζημιές. Δεν είχε συμβεί όμως το ίδιο με το σεισμό των 9,5 βαθμών, την ισχυρότερη δόνηση που έχει καταγραφεί ποτέ, σχεδόν στο ίδιο σημείο της Χιλής το 1960.

Τα κύματα που σήκωσε ο Εγκέλαδος σκότωσαν τότε 61 άτομα στη Χαβάη και 138 στην Ιαπωνία. Ο συνολικός απολογι-

σμός από το σεισμό και το τσουνάμι εκτιμάται στους 1.655 θανάτους.

Η Χιλή είναι άκρως σεισμογόνος περιοχή καθώς βρίσκεται πάνω σε μια ζώνη υποβύθισης -την περιοχή στην οποία μια ηπειρωτική πλάκα βυθίζεται κάτω από μια δεύτερη πλάκα και υποχωρεί μέσα στον γήινο μανδύα.

Η ζώνη υποβύθισης στις ακτές της Νοτίου Αμερικής στον Ειρηνικό είναι μέρος του λεγόμενου Δακτύλιου της Φωτιάς, μια σειρά μεγάλων ηφαιστείων που περιβάλλει τον Ειρηνικό και αντιστοιχεί στα όρια τεκτονικών πλακών.

Σύμφωνα με την αμερικανική Εθνική Υπηρεσία Ωκεανών και Ατμόσφαιρας (NOAA), την υπηρεσία που δημιούργησε το παραπάνω animation, ο δεύτερος ισχυρότερος σεισμός που έχει καταγραφεί ποτέ χτύπησε την Αλάσκα το 1964 και σήκωσε τσουνάμι που έπνιξε 11 ανθρώπους στην Καλιφόρνια, περίπου 3.000 χιλιόμετρα μακριά, και ακόμα 117 ανθρώπους σε άλλες περιοχές. Σε ορισμένα σημεία τα κύματα είχαν ύψος έως 67 μέτρα.

Η προσομοίωση καλύπτει διάστημα 30 ωρών (Πηγή: NOAA/ NWS/Pacific Tsunami Warning Center)

(Newsroom ΔΟΛ, 04 Απρ. 2014, <http://news.in.gr/science-technology/article/?aid=1231309070&ref=newsletter>)



### **Earthquake Deflection Takes a Tiny Step**

This week a massive quake off the coast of Chile killed six and forced hundreds of thousands to evacuate in fear of a tsunami. The shaking evoked memories of the events off the coast of Japan in 2011 that triggered meltdowns at a nuclear power plant that the country is still struggling with.

Scientists have long dreamed of ways to predict and even protect regions from such devastation. Now a group of French scientists hopes to help, building on work that showed how light can be manipulated to make objects invisible.

The cloaking technique (How Does Cloaking Work? <http://www.scientificamerican.com/article/how-does-cloaking-work-web-exclusive>) renders an object invisible by bending light of specific frequencies around the target. In theory, the same principles might be used to deflect incoming seismic waves. A precisely tuned array of boreholes around a city or a nuclear power plant that resonate at the frequencies characteristic of quakes could thus dampen the vibrations and shield objects.

The French team's small demo with acoustic waves in soil worked, deflecting the incoming energy around the target area. That research is in the journal *Physical Review Letters* [S. Brûlé, Experiments on Seismic Metamaterials: Molding Surface Waves]<sup>(1)</sup>.

Of course, that energy still has to go somewhere. Should this work pan out, the trick will be to find a way to absorb the massive energy of a major earthquake - or find a better place to send it (<https://www.youtube.com/watch?v=kqD0pqDOAtk>).

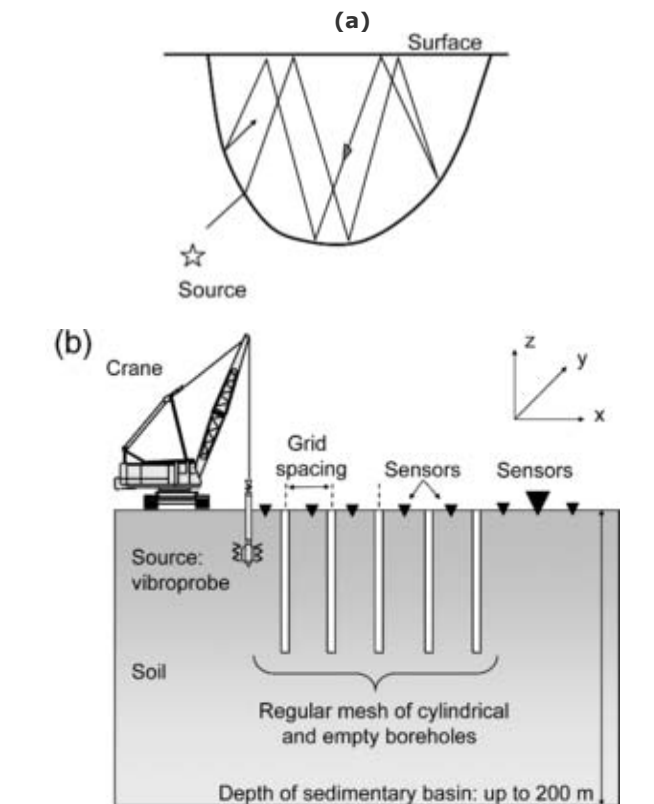
(David Biello / Scientific American, Apr 6, 2014, <http://www.scientificamerican.com/podcast/episode/earthquake-deflection-takes-a-tiny-step/>)



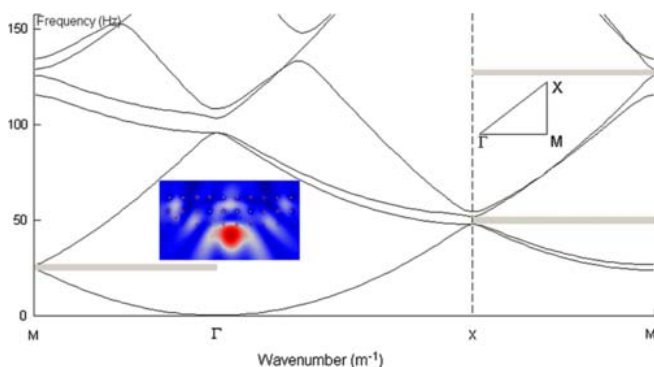
## <sup>(1)</sup> Experiments on Seismic Metamaterials: Molding Surface Waves

S. Brûlé, E. H. Javelaud, S. Enoch, and S. Guenneau  
*Phys. Rev. Lett.* **112**, 133901 – Published 31 March 2014

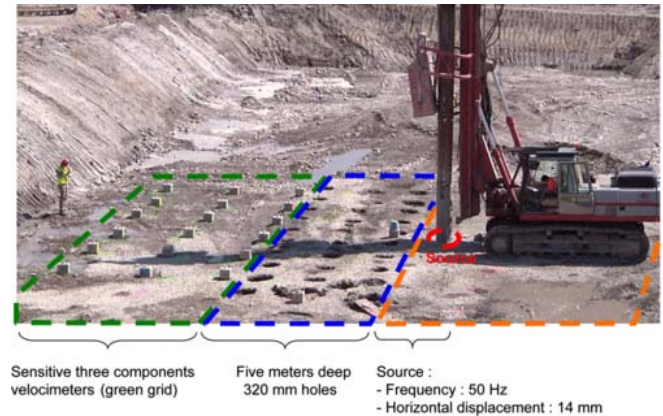
**ABSTRACT.** Materials engineered at the micro- and nano-meter scales have had a tremendous and lasting impact in photonics and phononics. At much larger scales, natural soils civil engineered at decimeter to meter scales may interact with seismic waves when the global properties of the medium are modified, or alternatively thanks to a seismic metamaterial constituted of a mesh of vertical empty inclusions bored in the initial soil. Here, we show the experimental results of a seismic test carried out using seismic waves generated by a monochromatic vibrocompaction probe. Measurements of the particles' velocities show a modification of the seismic energy distribution in the presence of the metamaterial in agreement with numerical simulations using an approximate plate model. For complex natural materials such as soils, this large-scale experiment was needed to show the practical feasibility of seismic metamaterials and to stress their importance for applications in civil engineering. We anticipate this experiment to be a starting point for smart devices for anthropic and natural vibrations.



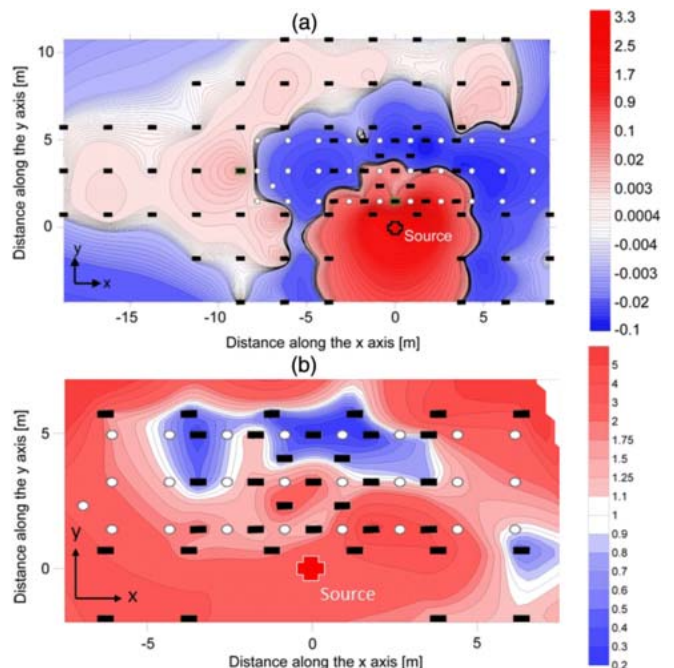
**Figure 1.** Schematics of (a) a seismic wave in an alluvium basin and (b) the seismic testing device cross section in the x-z plane (see Fig. 3 for a photograph of the experiment).



**Figure 2.** Simulated dispersion curves [frequency versus Bloch wave number describing the reduced Brillouin zone of vertices  $\Gamma=(0,0)$ ,  $X=(\pi/d,\pi/d)$ ,  $M=(\pi/d,0)$ ] for a periodic plate of pitch  $d=1.73$  m and thickness 5 m, with inclusions of diameter 0.32 m and density about 1/1000 that of the surrounding medium (soil). The inset shows the plot of flexural wave [i.e., displacement in the x-z plane in Fig. 1(b)] intensity for a forcing at 50 Hz (frequency in the second partial stop band along XM), which is located as in Fig. 4.



**Figure 3.** Photograph of the seismic metamaterial experiment from Ménard company. The three dashed perimeters account for the location of sensors [measuring the three components of wave velocity (green area on this photograph)], seismic metamaterial [5 m deep self-stable holes of diameter 0.32 m with center-to-center spacing of 1.73 m (blue area)], and rotating source (a vibrating probe set on a crane) with a horizontal displacement of 0.014 m generating an elastic wave at frequency 50 Hz.



**Figure 4.** Measurements for a monochromatic source. Experimental results' map after interpolation between sensors: (a) the difference (J2-J1) and (b) ratio (J2/J1), with image magnification on the metamaterial of the measured energy field (arbitrary units) after (J2) and before (J1) carrying out the boreholes. Note that the dark blue region in panel (b) has 5 times less elastic energy after we carried out the boreholes. Note also the small values of J1 about 10 meters away from the source (viscoelastic soil) make J2/J1 artificially high on the upper edge of the map, and should be disregarded. Black rectangles symbolize sensors, white circles symbolize the holes, and the red cross symbolizes the source.

## Viewpoint: A Step Towards a Seismic Cloak

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A large-scale experiment shows that a periodic array of boreholes embedded in the soil can deflect the energy of an incoming seismic wave.

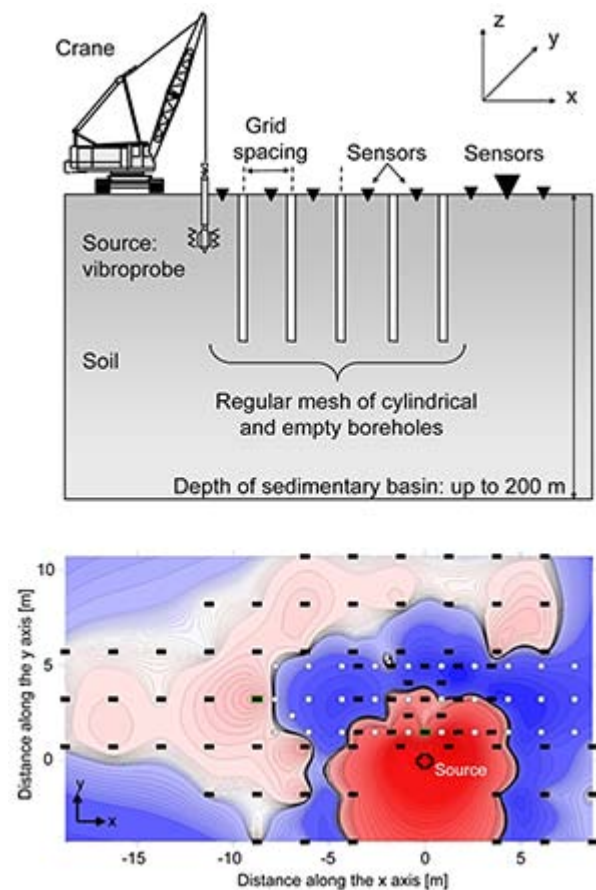
Phononic, photonic crystals and metamaterials are man-made structures that can control sound and light in ways not found in nature. Whereas the properties of phononic and photonic crystals derive from the periodicity of their structure, those of metamaterials arise from the collective effect of a large array of small resonators. These effects can be used to manipulate acoustic and electromagnetic waves in unconventional ways, realizing functions such as invisibility cloaking, subwavelength focusing, and unconventional refraction phenomena (such as negative refractive index and phase velocity). Recent work has started to explore another intriguing domain of application: using similar concepts to control the propagation of seismic waves within the surface of the Earth. Now, the research group of Sebastien Guenneau at the Aix-Marseille University and French National Center for Scientific Research (CNRS) has teamed up with civil engineers at an industrial company, Ménard, in Nozay, also in France, and carried out the largest-scale test to date of seismic metamaterials [1]. The reported experimental results are encouraging: an artificial structure built around a target can be used to deflect incoming acoustic waves at a frequency relevant to earthquake protection. This preliminary success in the laboratory could one day translate into a way of mitigating the destructive effects of earthquakes.

When an earthquake occurs, seismic waves are created by slip zones deep below the Earth's surface. When these underground waves [which can be longitudinal waves (*P* waves) or transverse waves (*S* waves)] meet the surface, part of their energy is converted into waves that propagate along the Earth's surface. These surface waves, also called Rayleigh waves, are usually observed in the frequency range of less than 1 hertz to a few tens of hertz, since the higher frequency components are more effectively attenuated during wave propagation. They have a much slower speed, hence a smaller wavelength, than underground waves and are usually the most destructive seismic waves. Can such seismic surface waves be deflected, cloaked, or blocked so as to protect a certain area from their destructive effects?

In recent years, a number of groups [2, 3, 4] have reported schemes, based on metamaterials made of properly tailored concentric rings, for cloaking objects from elastic bending waves propagating in thin plates. Given the similarity between acoustic and seismic phenomena, it was natural to envision that larger-scale analogs of acoustic metamaterials, called seismic metamaterials, could open a new direction in the control of seismic waves and protection from earthquakes. Building on the results obtained in the field of phononic crystals and acoustic metamaterials, theorists have proposed artificial structures, based on periodic arrays of boreholes, that exhibit band gaps at frequencies characteristic of seismic waves [5, 6, 7]. Such stop bands are due to, as in a phononic crystal, wave-interference phenomena: each borehole scatters a seismic wave, and because of the periodicity of the structure, the scattered waves would cancel each other out in certain directions as a result of destructive interference. Few small-scale experiments have been carried out on idealized model systems [2, 3, 4], yet seismic cloaking is much more complex than the cloaking of acoustic waves in thin, isotropic plates whose elastic properties are rather straightforward to model and characterize.

This is, in particular, due to the complex properties of the soil: a soft, anisotropic, and irregular propagation medium. As a consequence, the realization of large-scale experiments for demonstrating such effects represents a huge challenge.

Now, Guenneau and his colleagues have carried out such a large-scale test to assess the practical feasibility of seismic metamaterials. Their scheme consists of a periodic two-dimensional mesh of cylindrical, empty boreholes of 0.32 m diameter drilled 5 m deep into the top soil layer, with a lattice constant of 1.73 m [see Fig 1(a)]. An oscillating probe held by a crane was placed at a distance of 1.5 m from the borehole array, providing a source of monochromatic (50 Hz) acoustic waves impinging on the mesh. Guided by theoretical simulations, they chose such values of the geometric parameters so that the experimental frequency of 50 Hz should coincide with the directional band gap created by the periodic borehole array. In their calculations, the authors have modeled the surface wave using an elastic plate model in which the plate's flexural wave has a similar speed (78 m/s) as the measured Rayleigh wave. An array of sensors was placed in the experimental area to measure the wave intensity without the seismic shield (before the boreholes were drilled) and with the borehole array.



S. Brûlé *et al.*, Phys. Rev. Lett. (2014)

**Figure 1** (a) Scheme of the testing device for seismic metamaterials. An oscillating probe generates acoustic waves at 50 Hz in front of a mesh of cylindrical boreholes. An array of sensors monitors the intensity of the waves at various positions. (b) Experimental results. The map (black rectangles: sensors; white circles: boreholes; red cross: source) plots the difference of energy after and before drilling the boreholes. The dark blue region behind the holes indicates that the presence of the borehole mesh results in a decrease of elastic energy transmitted to that area. The red region indicates the area close to the source in which the wave intensity increases because of reflection.



The results of their measurements show a clear reflection effect exerted by the periodic array [see Fig. 1(b)]: two rows of boreholes away from the source, the measured intensity of the elastic energy decreases by at least a factor of 2, as compared to the no-borehole case. Since much of the wave energy is reflected, the area around the source instead shows an increase in intensity by a factor of 2. The agreement with their simulations provides the evidence that this effect arises from a directional stop gap due to the periodicity of the protecting array. The experiment so far realizes a gap in a single direction and at a precisely defined frequency. But, as has been demonstrated in the optical regime, in the near future, similar schemes may expand the directional gap to a full gap, independent of the direction of the incident wave. And while this prototype stop gap only works at a narrow frequency range around 50 Hz, more sophisticated versions may expand the gap to cover the actual seismic frequency range. Such schemes would then be able to lower the seismic surface wave intensity at some specified location during a real earthquake.

The authors are careful in pointing out the experimental and theoretical limitations of their work: the monochromatic and monodimensional gap as well the difficulty in modeling the top layer of the soil as an elastic medium. Yet the present experiment is indicative of the potential of using these acoustic-wave-manipulation strategies on a large scale, with an eye towards eventually realizing schemes for the mitigation of earthquake damage. However, it is worth noting that the scheme blocks and cloaks seismic surface waves by redirecting the wave energy elsewhere, which could worsen the earthquake's effects in the area surrounding the protected region. But recent theoretical work [6] has suggested a better option: dampening of the seismic waves could be done by absorbing the energy carried by those waves or even transforming it into other forms of energy, which could be stored for useful purposes. While this remains only a distant vision, the present experiment has opened a door for such grand thoughts.

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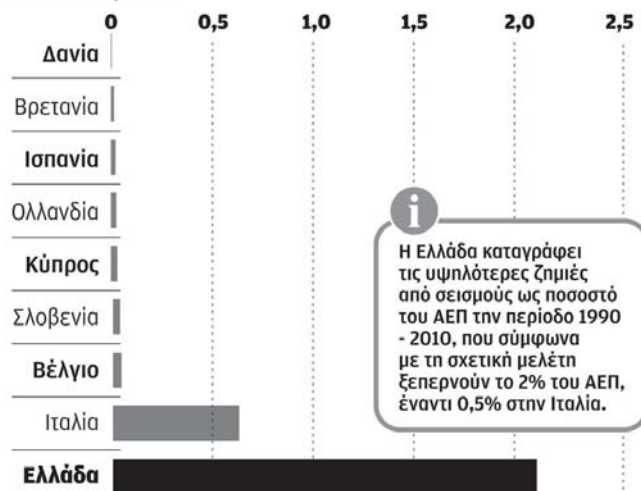
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## Στα 10 δισ. ευρώ το κόστος των ζημιών από τους σεισμούς από το 1980

### Ζημιές από σεισμούς

% του ΑΕΠ, 2010



ΠΗΓΗ: NatCat: Risk Relevance and Insurance in the EU - Σεπτέμβριος 2012

Η ΚΑΘΗΜΕΡΙΝΗ

Στα 350 εκατ. ευρώ ετησίως υπολογίζεται το μέσο κόστος των ζημιών από τους σεισμούς των τελευταίων 35 χρόνων, που στοίχισαν συνολικά στο κράτος περί τα 10 δισ. ευρώ. Το ποσό αυτό καταβλήθηκε με τη μορφή έκτακτων αποζημιώσεων από την Πολιτεία, δεδομένου ότι η συντριπτική πλειονότητα των κατασκευών στη χώρα μας είναι ανασφάλιστη.

Μιλώντας σε ειδική ημερίδα που διοργάνωσε χθες η Ένωση Ασφαλιστικών Εταιρειών Ελλάδος (ΕΑΕΕ) με θέμα «Η διαχείριση ζημιών σε περίπτωση φυσικών καταστροφών», ο πρόεδρος της ΕΑΕΕ Αλέξανδρος Σαρρηγεωργίου παραδέχθηκε ότι η συζήτηση που είχε ξεκινήσει με στόχο τη δημιουργία ενός ταμείου, που θα αναλάμβανε την καταβολή των αποζημιώσεων σε περίπτωση ενός σεισμού, έχει παγώσει, υπό το βάρος της «ανώριμης προσέγγισης» της οποίας έτυχε -όπως υποστήριξε- το θέμα. Ο δημόσιος διάλογος πήρε «λαϊκίστικο χαρακτήρα», υποστήριξε ο κ. Σαρρηγεωργίου, με συνέπεια η ασφάλιση να αντιμετωπιστεί ως ακόμη ένα «χαράτσι» στα ακίνητα και η σχετική συζήτηση να σταματήσει πρόωρα. Σύμφωνα με τον πρόεδρο της ΕΑΕΕ, η οικονομική αδυναμία που βιώνει η χώρα συνηγορεί υπέρ της ανάγκης για περισσότερη ασφάλιση προκειμένου να επιμεριστεί ο κίνδυνος και οι πολίτες να μην αναλάβουν στο ακέραιο το βάρος των ζημιών που θα προκληθούν από ένα καταστροφικό γεγονός.

Η ανάγκη αυτή καθίσταται επιτακτική, καθώς, όπως σημείωσε ο πρόεδρος της Επιτροπής Περιουσίας Αντασφαλίσεων, Μεταφορών και Σκαφών της ΕΑΕΕ, Ν. Βαγιακάκος, η χώρα μας συγκεντρώνει το 50% της σεισμικής επικινδυνότητας στην Ευρώπη και «ο σεισμός δεν αποτελεί πιθανότητα, αλλά αντίθετα βεβαιότητα. Αγνωστο παράγοντα συνιστά ο χρόνος στον οποίο θα λάβει χώρα» και για αυτό η πρόταση της ένωσης είναι η προχρηματοδότηση του κινδύνου από την ίδια την ασφαλιστική αγορά. Τα στοιχεία για το χαμηλό ποσοστό ασφάλισης των κτιρίων στην Ελλάδα, που επιβεβαιώθηκαν και στον πρόσφατο σεισμό της Κεφαλονιάς, όπου κάλυψη είχε μόλις ένα στα δέκα κτίρια, επιβεβαιώνουν ότι η συμμετοχή της ασφαλιστικής αγοράς στις αποζημιώσεις είναι περιορισμένη, παρά το γεγονός ότι η ικανότητα επιμερισμού του κινδύνου μέσω αντασφάλισης είναι ισχυρή.

Η μελέτη που έχει γίνει για το θέμα από τον καθηγητή Ασφαλιστικής Επιστήμης στο Πανεπιστήμιο Πειραιώς, Μιλτιάδη Νεκτάριο, δείχνει ότι το ποσοστό διείσδυσης της ασφάλισης στις καλύτερες σεισμού είναι ιδιαίτερα υψηλό σε χώρες όπως το Βέλγιο, η Ιρλανδία, η Ισπανία, η Γαλλία, η Σουηδία και η Αγγλία, που το σχετικό ποσοστό φθάνει το 90%. Ακολουθούν η Τσεχία, η Γερμανία και η Σλοβενία με ποσοστά από

25% ως 75%, ενώ η Ελλάδα ανήκει στην κατηγορία των χωρών με τα χαμηλότερα ποσοστά διείσδυσης -κάτω του 10%- μαζί με τη Βουλγαρία, την Ιταλία, την Αυστρία, την Πορτογαλία και τη Ρουμανία.

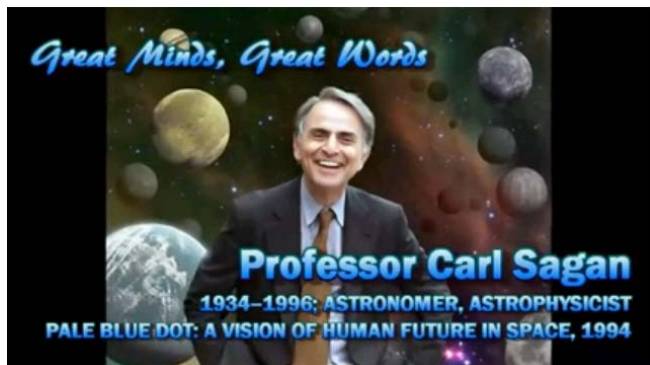
Την ίδια στιγμή η Ελλάδα καταγράφει τις υψηλότερες ζημιές από σεισμούς ως ποσοστό του ΑΕΠ την περίοδο 1990-2010, που σύμφωνα με τη σχετική μελέτη ξεπερνούν το 2% του ΑΕΠ, έναντι 0,5% στην Ιταλία. Ο βαθμός διείσδυσης της ιδιωτικής ασφάλισης καθορίζει με τη σειρά του και τον βαθμό εμπλοκής του κράτους ή την υποχρέωση συμμετοχής των πολιτών σε σχήματα προχρηματοδότησης των πιθανών ζημιών από σεισμό. Με βάση τα στοιχεία, οκτώ ευρωπαϊκά κράτη (Βέλγιο, Γερμανία, Γαλλία, Ιταλία, Ολλανδία, Αυστρία, Πολωνία και Ρουμανία) έχουν συστήσει ταμεία προχρηματοδότησης, αλλά η συμμετοχή, λόγω της μεγάλης διείσδυσης της ιδιωτικής ασφάλισης, είναι εθελοντική και μόνο στη Ρουμανία είναι υποχρεωτική.

(Ευγενία Τζώρτζη / Η ΚΑΘΗΜΕΡΙΝΗ, 8 Μαΐου 2014, <http://www.kathimerini.gr/766062/article/oikonomia/ellhni-kh-oikonomia/sta-10-dis-eyrw-to-kostos-twn-zhmiwn-apo-toys-seismoys-apo-to-1980>)



# ΕΝΔΙΑΦΕΡΟΝΤΑ - ΠΕΡΙΒΑΛΛΟΝ

**Carl Sagan - Χλωμή Μπλε Κουκκίδα**  
**Ένα video που διδάσκει πολλά!**



Η Χλωμή Μπλε Κουκκίδα είναι μια φωτογραφία της Γης που τραβήχτηκε το 1990 από το Voyager 1 από απόσταση ρεκόρ, δείχνοντας αμυδρά τον πλανήτη μας μέσα στο αχανές διάστημα. Μετά από αίτημα του Carl Sagan το Voyager, καθώς εγκατέλειπε το ηλιακό μας σύστημα, έστρεψε για μια τελευταία φορά τις κάμερες προς τη Γη, τραβώντας τη φωτογραφία, από την οποία εμπνεύστηκε ο τίτλος του ομότιτλου βιβλίου.



## Διχάζει ο ενεργειακός θησαυρός της Ευρώπης

Διχασμένη παραμένει η Ευρώπη σχετικά με την πολιτική που σκοπεύει να ακολουθήσει στον κλάδο του σχιστολιθικού αερίου. Χώρες όπως η Γαλλία (όπου ενδεχομένως να βρίσκονται τα μεγαλύτερα κοιτάσματα στο υπέδαφος της Ε.Ε.) και η Βουλγαρία έχουν απαγορεύσει την «υδραυλική ρωγμάτωση» (ή fracking), τη διαδικασία δηλαδή που απαιτείται για την απελευθέρωση του φυσικού αερίου που είναι παγιδευμένο μέσα σε σχιστολιθικά πετρώματα.

Στη Γερμανία, η αντικατάσταση του FDP (Ελεύθερο Δημοκρατικό Κόμμα) από το SPD (Σοσιαλδημοκράτες) στον κυβερνητικό συνασπισμό συνοδεύτηκε από ένα μορατόριουμ στις έρευνες έως ότου επιλυθούν τα περιβαλλοντικά ζητήματα που προκύπτουν από τη διαδικασία.

### Οι υπέρμαχοι

Στην άλλη άκρη του φάσματος, η Πολωνία, απτόητη παρά τις νέες, δραστικά συρρικνωμένες εκτιμήσεις για κοιτάσματα και τις αποχωρήσεις ξένων πολυεθνικών, έχει συστήσει μία κοινοπραξία κρατικών εταιρειών πετρελαίου, εξορύξεων και ηλεκτρισμού, για να συνεχίσει τις έρευνες για μη συμβατικό αέριο.

Στη Βρετανία, ο Ντέιβιντ Κάμερον ισχυρίζεται ότι το μυστικό της βιομηχανικής αναγέννησης της χώρας του κρύβεται στα πετρώματα του σχιστόλιθου του Μπόουλαντ, στον αγγλικό Βορρά, και στα άλλα κοιτάσματα της χώρας.

Προ ολίγων ημερών, η Ευρωπαϊκή Επιτροπή εξέδωσε σύσταση με ένα βασικό πλαίσιο αρχών που θα διέπουν το fracking στις χώρες της Ευρωπαϊκής Ένωσης. Όπως σημειώ-

νεται στη σύσταση, «η περιβαλλοντική νομοθεσία της Ένωσης καταρτίστηκε σε μια εποχή κατά την οποία η υδραυλική ρωγμάτωση μεγάλου όγκου δεν χρησιμοποιείτο στην Ευρώπη. Συνεπώς, ορισμένες περιβαλλοντικές πτυχές που σχετίζονται με την έρευνα και την παραγωγή των υδρογονανθράκων για τις οποίες χρησιμοποιείται αυτή η πρακτική δεν καλύπτονται πλήρως από την ισχύουσα ενωσιακή νομοθεσία, ιδίως σε ό,τι αφορά τον στρατηγικό σχεδιασμό, την αξιολόγηση των υπόγειων κινδύνων, την ακεραιότητα των φρεάτων, τη βασική και την επιχειρησιακή παρακολούθηση, τη δέσμευση των εκπομπών μεθανίου και την κοινοποίηση πληροφοριών σχετικά με τις χημικές ουσίες που χρησιμοποιούνται σε κάθε φρέαρ».

### Κανόνες από την Ε.Ε.

Η θέσπιση κοινών ελάχιστων αρχών, κατά την Κομισιόν, «θα εξασφαλίζει ίσους όρους ανταγωνισμού και θα βελτιώνει την εμπιστοσύνη των επενδυτών και τη λειτουργία της ενιαίας αγοράς ενέργειας. Επίσης, αναμένεται ότι οι σαφείς και διαφανείς κανόνες θα μετριάσουν τις ανησυχίες του κοινού και ενδεχομένως την αντίθεσή του στην ανάπτυξη της εκμετάλλευσης του σχιστολιθικού αερίου».

Με λίγα λόγια, οι Βρυξέλλες είπαν στα κράτη-μέλη ότι, υπό την προϋπόθεση του σεβασμού των ελάχιστων αυτών κοινών αρχών (που δεν είναι καν νομικά δεσμευτικές), το καθένα είναι ελεύθερο να διαμορφώσει τη δική του πολιτική σχετικά με το σχιστολιθικό αέριο – μια στάση παρεμφερή με αυτή που τήρησε η ομοσπονδιακή κυβέρνηση των ΗΠΑ έναντι των πολιτειών.

### Δεν είναι Αμερική

Για μια σειρά λόγων, ωστόσο, θεωρείται εξαιρετικά αμφίβολο ότι η αμερικανική σχιστολιθική επανάσταση μπορεί να επαναληφθεί στην Ευρώπη, μειώνοντας τις τιμές της ενέργειας για τη βιομηχανία και οδηγώντας ακόμα και στον επαναπατρισμό βιομηχανικών θέσεων εργασίας από χώρες του αναπτυσσόμενου κόσμου.

Ένας βασικός λόγος αφορά τη γεωλογική δομή των ευρωπαϊκών κοιτασμάτων. Σύμφωνα με τη Φλόρενς Τζένι του Ινστιτούτου Ενεργειακών Σπουδών του Πανεπιστημίου της Οξφόρδης («Can Unconventional Gas be a Game-Changer in European Gas Markets? »): «Συγκρινόμενες με τη Βόρεια Αμερική, οι λεκάνες μη συμβατικού αερίου της Ευρώπης τείνουν να είναι μικρότερες, τεκτονικά πιο περίπλοκες και οι γεωλογικές μονάδες φαίνεται να είναι πιο κατακερματισμένες».

Επιπλέον, οι (ευρωπαϊκοί) σχιστόλιθοι τείνουν να βρίσκονται βαθύτερα, να είναι θερμότεροι και πιο πεπιεσμένοι (...) και με περισσότερο άργιλο στη σύστασή τους». Αυτό σημαίνει ότι το κόστος της εξόρυξης θα είναι αυξημένο και τα αποτελέσματά της πιο αβέβαια.

Το κόστος θα είναι αυξημένο επίσης γιατί οι περιβαλλοντικοί κανονισμοί στις ευρωπαϊκές χώρες θα είναι αυστηρότεροι από ό,τι σε αμερικανικές πολιτείες με ιστορικό φιλικών σχέσεων με τον κλάδο των υδρογονανθράκων, όπως το Τέξας και η Πενσυλβάνια.

### Διαδηλώσεις στην Αγγλία

Ένα ακόμη πρόβλημα είναι πως οι περιοχές όπου βρίσκονται τα ευρωπαϊκά κοιτάσματα τείνουν να είναι πολύ πιο πυκνοκατοικημένες από τις αντίστοιχες αμερικανικές, κάτι που συνεπάγεται μεγαλύτερες αντιδράσεις των τοπικών κοινωνιών. Σύμφωνα με τον Διεθνή Οργανισμό Ενέργειας (IEA), «αφού ξεκινήσει η εξόρυξη, συνήθως είναι σε λειτουργία όλο το 24ωρο, προκαλώντας θόρυβο και αναθυμιάσεις από τις ντιζελογεννήτριες, απαιτώντας φώτα τη νύχτα και δημιουργώντας μια σταθερή ροή δρομολογίων φορτηγών» που μεταφέρουν το νερό που απαιτείται, σε μια διαδικασία που μπορεί να διαρκέσει «από μερικές ημέρες έως αρκετούς μήνες».

Οι διαδηλωτές που κατασκήνωσαν τον περασμένο Αύγουστο έξω από το χωριό Μπάλκομπ στο δυτικό Σάσεξ στη νότια Αγγλία, τασσόμενοι κατά των ερευνών για πετρέλαιο που σχεδίαζε στην περιοχή η αμερικανική εταιρεία Cuadrilla, η οποία είχε πάρει άδεια και για fracking, αποτελούν χαρακτηριστικό προοίμιο του τι μπορεί να επακολουθήσει αν ο Κάμερον επιμείνει στα σχιστολιθικά του οράματα.

Τρίτον, σε αντίθεση με τις ΗΠΑ, οι ιδιοκτήτες γης στην Ευρώπη δεν αποκτούν δικαιώματα και επί του ορυκτού πλούτου που βρίσκεται στο υπέδαφος των οικοπέδων του. Αυτό σημαίνει ότι δεν θα έχουν τα ίδια κίνητρα να στηρίξουν τις έρευνες όπως οι Αμερικανοί.

### Πρώτες ενδείξεις σε Ήπειρο και Θράκη

Υπάρχουν τέσσερις εκτεταμένες λεκάνες σχιστολιθικού αερίου στα εδάφη της Ε.Ε.: από την ανατολική Δανία και τη νότια Σουηδία έως τη νοτιοανατολική Πολωνία προς τα νότια και τις χώρες της Βαλτικής προς τα βόρεια· από τη βορειοδυτική Αγγλία έως τη βόρεια Γερμανία μέσω της Ολλανδίας· από τη νότια Αγγλία έως την περιοχή του Παρισιού στη Γαλλία· και από τη Σλοβακία και την Ουγγαρία νότια μέσω της Ρουμανίας έως τις βουλγαρικές ακτές της Μαύρης Θάλασσας. Όπως σημειώνει το Oxford Institute for Energy Studies, οι εκτιμήσεις για τα μεγέθη του αερίου που μπορεί να ανακτηθεί διαφέρουν πολύ μεταξύ τους, γιατί έχουν γίνει πολύ λίγες δοκιμαστικές γεωτρήσεις στη Γηραιά Ήπειρο. Σύμφωνα με μία ανασκόπηση υπαρχουσών πηγών που διεξήγαγε το Joint Research Centre της Ε.Ε. το 2012, η χαμηλή εκτίμηση ήταν 2,3 τρισ. κυβικά μέτρα (έναντι 13 τρισ. στις ΗΠΑ), η καλύτερη εκτίμηση ήταν 15,9 τρισ. κ.μ. (20 τρισ. στις ΗΠΑ) και η υψηλή εκτίμηση ήταν 17,6 τρισ. κ.μ. (47 τρισ. στις ΗΠΑ). Καθώς αυξάνονται οι δοκιμαστικές γεωτρήσεις, είναι πιθανό οι εκτιμήσεις αυτές να πολλαπλασιαστούν. (Ωστόσο, στην Πολωνία, οι τελευταίες μετρήσεις της Γεωλογικής Εταιρείας της χώρας ήταν χαμηλότερες κατά 90% από τις προηγούμενες εκτιμήσεις.) Στην Ελλάδα, προκαταρκτική μελέτη του ΙΓΜΕ το 2011 βρήκε ενδείξεις αποθεμάτων στην Ήπειρο και τη Θράκη (κυρίως στην περιοχή της Ορεστιάδας). Έκτοτε δεν έχουν υπάρξει πιο λεπτομερείς μελέτες, που να επιβεβαιώνουν την ύπαρξη κοιτασμάτων και το μέγεθός τους, που ωστόσο δεν εκτιμάται ότι είναι μεγάλο.

### Τι μπορεί να προκαλέσει ένα «πηγάδι» 3.000 μέτρων

Πέρα από το θέμα του κόστους και της βιομηχανικής ανταγωνιστικότητας, το δεύτερο βασικό επιχείρημα υπέρ της εκμετάλλευσης των σχιστολιθικών κοιτασμάτων συνδέεται με την ενεργειακή ασφάλεια. Όπως σημειώνει στην «Κ» η Νίκη Τζαβέλα, ευρωβουλευτής και εισηγήτρια έκθεσης για το σχιστολιθικό αέριο στο Ευρωπαϊκό Κοινοβούλιο: «Μόνο αν ξαναρχίσει να παράγει τον ενδογενή πλούτο της θα μπορέσει η Ευρώπη, και κατά επέκταση τα κράτη-μέλη, να ορίσουν καλύτερες ενεργειακές τιμές και να μην εξαρτιόμαστε από την πολιτική της Gazprom, που ορίζει τις τιμές φυσικού αερίου σύμφωνα με τον δείκτη του αργού πετρελαίου». Επιπλέον, όπως εξηγεί, «ο συνδυασμός παραγωγής φυσικού αερίου στην Ευρώπη και το ενδεχόμενο εμπορικής συμφωνίας Ε.Ε.-ΗΠΑ που θα συμπεριλαμβάνει την εισαγωγή αμερικανικού αερίου θα αλλάξουν τις ισορροπίες στην αγορά».

Ο κυριότερος ανασταλτικός παράγοντας για την ανάπτυξη του σχιστολιθικού αερίου στην Ευρώπη είναι οι φόβοι για τις περιβαλλοντικές συνέπειες. Η «υδραυλική ρωγμάτωση» συνίσταται, σε πρώτη φάση, στην κάθετη γεώτρηση (σε βάθος τουλάχιστον 2-3 χλμ.) προς αναζήτηση του σχιστολιθικού στρώματος. Στη συνέχεια, γίνεται οριζόντια γεώτρηση του στρώματος, το πηγάδι επενδύεται με χάλυβα και τσιμέντο και γίνεται έγχυση νερού που περιέχει άμμο και χημικές ουσίες, με πολύ υψηλή πίεση. Το υγρό αυτό μείγμα δημιουργεί μικρές ρωγμές στον σχιστόλιθο, από τις οποίες αντλείται το παγιδευμένο αέριο.

Στους πιθανούς κινδύνους συγκαταλέγονται η μόλυνση του υδροφόρου ορίζοντα, η απελευθέρωση μεθανίου (ενός αερί-

ου του θερμοκηπίου πολύ πιο ρυπογόνου από το διοξείδιο του άνθρακα) στην ατμόσφαιρα, η κυκλοφοριακή συμφόρηση και η πρόκληση σεισμών. Το περιβαλλοντικό λόμπι τάσσεται κατά του fracking, αναδεικνύοντας, εκτός από τους περιβαλλοντικούς κινδύνους, τις ψευδαισθήσεις σχετικά με τα πιθανά οφέλη του. Όπως σημειώνει προ μηνών το ευρωπαϊκό τμήμα της ΜΚΟ Friends of the Earth, «το σχιστολιθικό αέριο στην Ευρώπη, αν αποδειχθεί οικονομικά εφικτό, θα καταφθάσει με αργούς ρυθμούς, σε πολύ υψηλότερες τιμές από ό,τι στις Ηνωμένες Πολιτείες και θα είναι βιώσιμο μόνο αν υποστηριχθεί από μαζικές επιδοτήσεις από ευρωπαϊκές κυβερνήσεις. Οι επιδοτήσεις αυτές θα στήριζαν μία τεχνολογία που μολύνει τα αποθέματα υδάτων, διακινδυνεύει την υγεία των ανθρώπων και συμβάλλει στην επικίνδυνη κλιματική αλλαγή».

Η αναφορά στην κλιματική αλλαγή δεν είναι τυχαία. Οι υποστηρικτές του σχιστολιθικού αερίου χρησιμοποιούν μεταξύ άλλων και το περιβαλλοντικό επιχείρημα ότι η διάδοσή του θα οδηγήσει σε αντικατάσταση του άνθρακα και σε μείωση των εκπομπών αερίων του θερμοκηπίου. Στην Πολωνία, για παράδειγμα, όπου άνω του 90% της ηλεκτρικής ενέργειας εξακολουθεί να παράγεται από άνθρακα (κυρίως λιγνίτη), η στροφή –αν ευοδωθεί– στο σχιστολιθικό αέριο θα έχει ακριβώς αυτό το αποτέλεσμα. Στις ΗΠΑ, που δεν έχουν θεσπίσει σύστημα εμπορίας ρύπων και που δεν επικύρωσαν το Πρωτόκολλο του Κιότο, οι εκπομπές αερίων που συνδέονται με την καύση άνθρακα μειώθηκαν κατά 3,8% το 2012, κυρίως χάρη στην ευρεία υιοθέτηση του σχιστολιθικού αερίου.

### Εξαγωγή άνθρακα

Ωστόσο, μία κρίσιμη παράπλευρη συνέπεια της εξέλιξης αυτής ήταν η εξαγωγή άνθρακα από τις ΗΠΑ στην Ευρώπη. Όπως δηλώνει στην «Κ» ο Τζο Χένον, εκπρόσωπος Περιβάλλοντος της Κομισιόν, «είναι δύσκολο να γνωρίζουμε» αν μακροπρόθεσμα μπορεί το εγχώριο παραγόμενο σχιστολιθικό αέριο να αντικαταστήσει τον άνθρακα και να συμβάλει στην άμβλυνση της κλιματικής αλλαγής. Όπως τονίζει δε, η αντικατάσταση αυτή δεν πρέπει να έχει τις ίδιες συνέπειες με το αμερικανικό προηγούμενο (την εκτόπιση των εκπομπών άνθρακα σε άλλη περιοχή του πλανήτη χωρίς τη μείωσή τους).

Σύμφωνα με τον Δημήτρη Ιμπραήμ, επικεφαλής εκστρατειών του ελληνικού τμήματος της Greenpeace, η Ευρώπη θα έπρεπε να δώσει έμφαση σε άλλες μεθόδους καταπολέμησης της κλιματικής αλλαγής, αντί της προώθησής του μη συμβατικού αερίου. Για την Ελλάδα συγκεκριμένα, εκφράζει την ανησυχία ότι η δίψα για επενδύσεις θα οδηγήσει σε «χαλαρή περιβαλλοντική νομοθεσία» σχετικά με την εκμετάλλευση του σχιστολιθικού αερίου, που συνεπάγεται αύξηση των περιβαλλοντικών και άλλων κινδύνων.

Όπως εξηγεί ο κ. Χένον, η Κομισιόν επέλεξε τον δρόμο της μη δεσμευτικής σύστασης, γιατί «η διαδικασία νομοθέτησης θα ήταν ιδιαίτερα περίπλοκη και ενδέχεται να μην είχε ολοκληρωθεί πριν από το 2017». Ωστόσο, καθώς οι δοκιμαστικές γεωτρήσεις πολλαπλασιάζονται, η Επιτροπή «θα παρακολουθεί στενά την εφαρμογή της σύστασης» και θα την επανεξετάσει «18 μήνες μετά τη δημοσίευσή της». Και σημειώνει με νόημα ο εκπρόσωπος Περιβάλλοντος, «αν δούμε τότε ότι είναι απαραίτητο, θα λάβουμε νομοθετική πρωτοβουλία».

(Γιάννης Παλαιολόγος / Η ΚΑΘΗΜΕΡΙΝΗ ΟΙΚΟΝΟΜΙΚΗ, Κυριακή 9 Φεβρουαρίου 2014, <http://www.kathimerini.gr/752973/article/oikonomia/die8n-hs-oikonomia/dixazei-o-energeiakos-8hsayros-ths-eyrwphs>)



## Με τη δύναμη του ηφαιστείου Γεωθερμικό εργοστάσιο αντλεί ενέργεια από μάγμα



Ο κρατήρας Βίτι του ηφαιστείου Κράφλα στην Ισλανδία. Στο φόντο, ατμός από το γεωθερμικό εργοστάσιο της περιοχής.

Μια ερευνητική γεώτρηση στην Ισλανδία η οποία χτύπησε κατά λάθος έναν ηφαιστειακό θάλαμο μάγματος οδήγησε τελικά στη δημιουργία του πρώτου γεωθερμικού συστήματος που αντλεί ενέργεια από τα λιωμένα πετρώματα του υπεδάφους.

Τα σημερινά γεωθερμικά εργοστάσια διοχετεύουν νερό σε θερμές ρωγμές μέσα στον στερεό γήινο φλοιό. Ο ατμός που παράγεται στο υπέδαφος ανεβαίνει στην επιφάνεια και τροφοδοτεί γεννήτριες που παράγουν ηλεκτρικό ρεύμα.

Το 2009, γεωλόγοι που συμμετέχουν στο Ισλανδικό Πρόγραμμα Βαθιάς Γεώτρησης αναζητούσαν νέα γεωθερμικά πεδία για το εκτεταμένο σύστημα γεωθερμικής ενέργειας στην ηφαιστειογενή Ισλανδία. Το αρχικό τους σχέδιο ήταν να ανοίξουν μια γεώτρηση σε βάθος 4 με 5 χιλιομέτρων κάτω από την καλδέρα του ηφαιστείου Κράφλα στα βόρεια της χώρας. Το γεωτρύπανο όμως έφτασε σε έναν θάλαμο μάγματος μόλις 2,1 χιλιόμετρα από την επιφάνεια.

Ήταν μόλις η δεύτερη φορά στα χρονικά της γεωλογίας που μια γεώτρηση φτάνει σε μάγμα, έπειτα από ένα προηγούμενο περιστατικό στη Χαβάη το 2007.

Οι γεωλόγοι στην Ισλανδία έσπευσαν να αξιοποιήσουν τη σπάνια ευκαιρία: έντυσαν εσωτερικά το φρεάτιο της γεώτρησης με ατσάλινα τοιχώματα στερεωμένα με τσιμέντο, και διοχέτευσαν μέσα στο σωλήνα νερό που μετατράπηκε αμέσως σε υπέρθερμο ατμό.

Με τη θερμοκρασία του μάγματος να υπερβαίνει τους 1.000 βαθμούς Κελσίου, ο ατμός τους 450 βαθμούς και ξεπηδούσε από το φρεάτιο με μεγάλη πίεση, αρκετή για να προσφέρει ενέργεια επτά φορές περισσότερη από ό,τι σε ένα τυπικό γεωθερμικό φρεάτιο. Η ισχύς εκτιμάται στα 36 Megawatt, αρκετή για την ηλεκτροδότηση μιας μικρής πόλης.

Η γεώτρηση δεν συνδέθηκε ποτέ με τη γεωθερμική μονάδα που λειτουργεί στο ηφαίστειο Κράφλα, οι ερευνητές όμως πέρασαν δύο χρόνια πραγματοποιώντας δοκιμές, προκειμένου να διαπιστώσουν αν ο εξοπλισμός άντεξε την υψηλή πίεση του ατμού και τη διάβρωση που προκαλούν τα όξινα ηφαιστειακά αέρια.

Το φρεάτιο της γεώτρησης σφραγίστηκε όταν ο εξοπλισμός στην επιφάνεια παρουσίασε βλάβες, οι ερευνητές όμως πιστεύουν ότι έχουν βρει λύση στο πρόβλημα και σχεδιάζουν νέα γεώτρηση στην ίδια περιοχή.

«Μέχρι σήμερα δεν έχουν καταβληθεί αρκετές προσπάθειες προκειμένου να διερευνήσουμε το δυναμικό του μάγματος

ως πηγής ενέργειας, αν και στις ΗΠΑ έχει εκδηλωθεί ενδιαφέρον εδώ και δύο δεκαετίες» αναφέρει ο Ουίλφρεντ Έλντερς, μέλος της ερευνητικής ομάδας που υπογράφει τη σχετική δημοσίευση στην επιθεώρηση Geothermics.

«Πιστεύω ότι θα ήταν σκόπιμο να ανανεώσουμε αυτό το ενδιαφέρον» επισημαίνει.

(Newsroom ΔΟΛ, 28 Ιαν. 2014, <http://news.in.gr/science-technology/article/?aid=1231290879>)



## Πώς οι λύκοι μεταμορφώνουν το περιβάλλον

Ρίξτε μια ματιά σε αυτό το καταπληκτικό βίντεο που δείχνει πώς ένα είδος (οι λύκοι εν προκειμένω) μπορεί να έχει τεράστια επίδραση σε ολόκληρο το οικοσύστημα στο οποίο ζει, ακόμα και να αλλάξει την γεωγραφία μιας περιοχής: Όταν οι λύκοι τοποθετήθηκαν εκ νέου στο εθνικό πάρκο Yellowstone των Ηνωμένων Πολιτειών, ενώ απουσίαζαν για σχεδόν 70 χρόνια, συνέβη η πιο αξιοσημείωτη "τροφική μεταμόρφωση".

Ως γνωστόν, οι λύκοι σκοτώνουν κάποια ζώα για τροφή τους, αυτό που δεν είναι όμως ευρέως γνωστό, είναι ότι με την παρουσία τους δίνουν ζωή σε κάποια άλλα είδη ζώων... τα οποία με τη σειρά τους μπορούν και να μεταμορφώσουν το φυσικό περιβάλλον στο οποίο ζούν...

Όλα αυτά τα φαινόμενα παρουσιάζονται και εξηγούνται γλαφυρά στο βίντεο που ακολουθεί ... "Πώς οι λύκοι μεταμορφώνουν το περιβάλλον".

<http://www.videoman.gr/54410>



# ΕΝΔΙΑΦΕΡΟΝΤΑ - ΛΟΙΠΑ

## Όλυμπος – Το βουνό των Θεών !!!

Μια γρήγορη περιήγηση στο μυθικό βουνό μέσα από την κάμερα του Ιωάννη Μπείντα. Προβλήθηκε στο Grito Rock Festival 2013 (3-3-2013) και στο Ελληνογερμανικό φόρουμ για την Ορεινή Πεζοπορία (7-12-2013). Δείτε το σε ανάλυση HD 1080p

[http://www.youtube.com/embed/qYT7pvfz308?feature=player\\_embedded](http://www.youtube.com/embed/qYT7pvfz308?feature=player_embedded)

<http://www.youtube.com/watch?v=qYT7pvfz308>



## Το σκυρόδεμα της Ρωμαϊκής Αυτοκρατορίας Η μυστική συνταγή αποτελείται από μείγμα ηφαιστειακής τέφρας αναμεμειγμένη με ασβέστη και θαλασσινό νερό

Δύο χιλιάδες χρόνια μετά την κατασκευή των πρώτων ρωμαϊκών λιμανιών αποκαλύπτεται η μυστική συνταγή του ανθεκτικού, εύκολου στη χρήση και περιβαλλοντικά φιλικού ρωμαϊκού τσιμέντου, που έφερε επανάσταση στις κατασκευές της εποχής.

«Η Ρωμαϊκή Αυτοκρατορία δεν θα υπήρχε χωρίς μεγάλα λιμάνια. Τα βασικά αγαθά, όπως το σιτάρι, το μάρμαρο ή η πέτρα έπρεπε να μεταφερθούν με πλοία» λέει ο Τζον Ολεσον, καθηγητής ελληνικών και ρωμαϊκών σπουδών στο Πανεπιστήμιο της Βικτώριας του Καναδά, και επικεφαλής μιας διεθνούς ομάδας επιστημόνων που μελετά το κατασκευαστικό υλικό που χρησιμοποίησαν οι Ρωμαίοι για να χτίσουν τα λιμάνια της αυτοκρατορίας τους στη Μεσόγειο. Από τις ακτές της Ιταλίας μέχρι την Αλεξάνδρεια της Αιγύπτου, και έως την Παράλιο Καισάρεια του Ισραήλ, δεκάδες λιμάνια της Μεσογείου φαίνεται να έχουν χτιστεί με το ίδιο ακριβώς υλικό, ένα μείγμα ηφαιστειακής τέφρας από τον κόλπο της Ναπολεις στην Ιταλία αναμεμειγμένη με ασβέστη και θαλασσινό νερό.

«Η πρώτη ερώτηση που έπρεπε να απαντήσουμε ήταν: Πώς είναι δυνατό αυτό το υλικό να έχει επιβιώσει άθικτο για 2.000 χρόνια μέσα στο θαλασσινό νερό;» λέει η Μαρί Τζάκσον, ερευνήτρια στο Τμήμα Πολιτικών Μηχανικών και Μηχανικών Περιβάλλοντος του Πανεπιστημίου της Καλιφόρνιας στο Μπέρκλεϊ, μέλος της παραπάνω ερευνητικής ομάδας και υπεύθυνη για τη μελέτη της σύστασης του ρωμαϊκού σκυροδέματος. Η Τζάκσον, προσπαθώντας να ανακαλύψει τι είναι αυτό που διαφοροποιεί το κατασκευαστικό υλικό των Ρωμαίων από το σκυρόδεμα που χρησιμοποιούμε σήμερα στα λιμάνια, η διάρκεια ζωής του οποίου δεν ξεπερνά συνήθως τα 100 χρόνια, έψαξε για απαντήσεις, στην ουσία εκείνη που λειτουργεί σαν κόλλα κρατώντας ενωμένα τα διαφορετικά συστατικά του μείγματος, το γνωστό μας τσιμέντο. Όπως αναφέρουν οι ερευνητές στα ευρήματά τους, που δημοσιεύθηκαν πρόσφατα στα επιστημονικά περιοδικά Journal of the American Ceramic Society και American Mineralogist, το ρωμαϊκό τσιμέντο περιέχει ενώσεις αλουμινίου.

«Το αλουμίνιο προέρχεται από την ηφαιστειακή τέφρα και πιστεύουμε ότι αυτό δίνει στο υλικό την ικανότητα να παραμένει σε ισορροπία με το θαλάσσιο περιβάλλον και να διατη-

ρείται», όπως λέει η Μαρί Τζάκσον. Η ομάδα του Μπέρκλεϊ ανακάλυψε επίσης ότι κατά τον σχηματισμό του ρωμαϊκού σκυροδέματος γίνεται μια αντίδραση που παράγει την ουσία Al-tobermorite, στην οποία, σύμφωνα με τους ερευνητές, κρύβεται η συνταγή της επιτυχίας αυτού του υλικού, η αντοχή του στον χρόνο.

## Περιβαλλοντικά φιλικό

Παρά τα πλεονεκτήματα του ρωμαϊκού σκυροδέματος η επιστημονική κοινότητα φαίνεται, στην πλειοψηφία της, ικανοποιημένη από τα κατασκευαστικά υλικά που χρησιμοποιούνται σήμερα ευρέως στα λιμενικά έργα. «Το σύγχρονο σκυρόδεμα μας καλύπτει πλήρως» λέει ο καθηγητής Ακτομηχανικής και Λιμενικών Εργων στο Αριστοτέλειο Πανεπιστήμιο Θεσσαλονίκης, Θεοφάνης Καραμπάς. «Δεν έχει φανεί η ανάγκη να ανακατασκευάσουμε το υλικό των Ρωμαίων» αναφέρει ο διευθυντής του Εργαστηρίου Λιμενικών Εργων του Εθνικού Μετσόβιου Πολυτεχνείου, καθηγητής Κωνσταντίνος Μουτζούρης, προσθέτοντας ότι «το τσιμέντο άλλωστε είναι ένα σχετικά σύγχρονο υλικό και δεν έχουμε δει ακόμα τα εμφανή σημάδια γηράνσεώς του».

Παρ' όλα αυτά, σύμφωνα με τους ερευνητές του Πανεπιστημίου του Μπέρκλεϊ, η παραγωγή τσιμέντου σήμερα ευθύνεται για το 7% των εκπομπών διοξειδίου του άνθρακα στην ατμόσφαιρα, κάτι που δεν προκαλεί έκπληξη, αφού κάθε χρόνο παράγονται παγκοσμίως πάνω από 25 δισεκατομμύρια τόνοι. «Μόνο νερό χρησιμοποιούμε σε μεγαλύτερες ποσότητες» τονίζει ο καθηγητής Ολεσον.

Σήμερα, για να κατασκευαστεί το τσιμέντο, η πρώτη ύλη χρειάζεται να θερμανθεί σε θερμοκρασίες που φτάνουν τους 1.450 βαθμούς Κελσίου. Στη συνέχεια προστίθεται άμμος, χαλίκια και νερό, ενώ τέλος η κατασκευή ενισχύεται με αστάλι. Αντίθετα, στο ρωμαϊκό σκυρόδεμα η ηφαιστειακή τέφρα προστέθηκε στο μείγμα ακριβώς όπως συλλέχθηκε από τη φύση, ενώ για τις μικρές ποσότητες ασβέστη που χρησιμοποιήθηκαν, ο ασβεστόλιθος ψήθηκε σε θερμοκρασία που δεν ξεπερνά τους 900 βαθμούς Κελσίου. Οι Ρωμαίοι κατασκεύαζαν ξύλινα καλούπια, τα βύθιζαν στη θάλασσα, και μέσα σε αυτά έριχναν την τέφρα και τον ασβέστη, αφήνοντας τα θαλασσινό νερό να μπει από τις σχισμές της ξύλινης κατασκευής και να «δέσει» τα υλικά. «Η σημαντικότερη συνεισφορά αυτής της έρευνας είναι ότι μέτρησαν το περιβαλλοντικό κόστος των σημερινών τσιμέντων, το οποίο είναι πολύ υψηλό σε σχέση με αυτό των Ρωμαίων» λέει ο καθηγητής Θαλάσσιας Υδραυλικής και Λιμενικών Εργων του ΕΜΠ, Κωνσταντίνος Μέμος.

## Δείγματα από αρχαία λιμάνια του Αιγαίου

Ανάμεσα στα έντεκα λιμάνια που μελέτησε η διεθνής ερευνητική ομάδα ήταν και το Ρωμαϊκό λιμάνι της Χερσονήσου στην Κρήτη, το μοναδικό μέχρι στιγμής ελληνικό λιμάνι στο οποίο έχει ανακαλυφθεί η χρήση ρωμαϊκού σκυροδέματος. «Το σκυρόδεμα που χρησιμοποιήθηκε στη Χερσονήσο είναι κάπως διαφορετικό από αυτό των υπολοίπων λιμανιών της Μεσογείου, είναι πιο πορώδες» λέει η δρ Τζάκσον, εξηγώντας ότι ενώ στο μείγμα χρησιμοποιήθηκε πράγματι ηφαιστειακή τέφρα από τον κόλπο της Νάπολης και συγκεκριμένα από την περιοχή Ποτσουόλι, οι ποσότητες ασβέστη ήταν μικρότερες. «Ο ασβέστης, από τότε, αποτελούσε το ακριβότερο υλικό. Ιστορικές πηγές αναφέρουν ότι πολλά κτίρια των Ρωμαίων κατέρρεαν επειδή οι κατασκευαστές "έκλεβαν" στον ασβέστη. Δεν είναι μόνο σύγχρονο το φαινόμενο» συμπληρώνει ο καθηγητής Ολεσον.

«Παρουσιάζει ενδιαφέρον το γεγονός ότι δεν απαντάται συχνά το ρωμαϊκό σκυρόδεμα στις ελληνικές παράκτιες περιοχές» αναφέρει ο ίδιος, εξηγώντας ότι κάτι τέτοιο πιθανόν να οφείλεται στο γεγονός ότι τον 1ο αιώνα π.Χ. στον ελληνικό χώρο υπήρχαν ήδη λιμάνια χτισμένα με ογκόλιθους, ενώ την ίδια στιγμή το Αιγαίο έχει πολλά φυσικά λιμάνια, με αποτέλεσμα να καλύπτονται οι ανάγκες των Ρωμαίων.



Μετά το τέλος του βου αιώνα π.Χ. τα λιμάνια του Αιγαίου αρχίζουν να είναι χτιστά, περιγράφει ο αρχαιολόγος της Εφορείας Εναλίων Αρχαιοτήτων, Θεοτόκης Θεοδούλου. «Μέχρι τότε τα σκάφη ήταν αγωγά, μετέφεραν δηλαδή πολεμικές, και στη συνέχεια τα έσερναν μέχρι την ακτή. Στο τέλος όμως του βου αιώνα π.Χ. τελειοποιείται η τριήρης σαν πολεμικό σκάφος και υπάρχει ανάγκη να τις προστατεύσουν» λέει ο κ. Θεοδούλου, μέλος μια ελληνικής επιστημονικής ομάδας που τα τελευταία χρόνια καταγράφει τα αρχαία ελληνικά λιμάνια, ενώ παράλληλα συγκεντρώνει και συνδυάζει αρχαιολογικά με τεχνικά στοιχεία σε έναν ιστότοπο με την ονομασία «Λιμενοσκοπίον». Ο Κωνσταντίνος Μέμος, εμπνευστής αυτής της προσπάθειας, εξηγεί ότι οι αρχαίοι Έλληνες κατασκευάζουν τα λιμάνια τους στοιβάζοντας πέτρες, ογκόλιθους, τη μία πάνω στην άλλη με έναν τρόπο που ονομάζεται έμπλεκτος. «Παρότι και οι Έλληνες χρησιμοποιούν ένα κόνιαμα, μια λάσπη, για να συνδέσουν τις πέτρες μεταξύ τους, αυτό δεν έχει τις ισχυρές συγκολλητικές ιδιότητες του υλικού των Ρωμαίων» λέει ο κ. Μέμος.

Παρ' όλα αυτά, πρόσφατες μελέτες της Εφορείας Εναλίων Αρχαιοτήτων, με την υποστήριξη του «Λιμενοσκοπίου», στο βόρειο λιμάνι της Μυτιλήνης έφεραν στην επιφάνεια ένα υλικό που έχει πολλές ομοιότητες με το ρωμαϊκό σκυρόδεμα. Το λιμάνι αυτό, που είναι γνωστό σήμερα ως Επάνω Σκάλα, υπολογίζεται ότι έχει χτιστεί τον 4ο αιώνα π.Χ., ενώ διατηρείται μέχρι σήμερα σε ιδιαίτερα καλή κατάσταση. Οι επιστήμονες Θεοδούλου και Μέμος λοιπόν, αναμένοντας την αναχρονολόγηση του δομικού υλικού που βρέθηκε στη Μυτιλήνη, κρατούν μια επιφύλαξη για το εάν οι Ρωμαίοι ήταν οι πρώτοι που χρησιμοποίησαν αυτό το είδος σκυροδέματος στην κατασκευή λιμανιών.

(Ασπασία Δασκαλοπούλου / Η ΚΑΘΗΜΕΡΙΝΗ, Σάββατο 4 Ιανουαρίου 2014, [http://news.kathimerini.gr/4dcgi/\\_w\\_articles\\_world\\_2\\_04/01/2014\\_544961](http://news.kathimerini.gr/4dcgi/_w_articles_world_2_04/01/2014_544961))

## THE ROMAN MARITIME CONCRETE STUDY (ROMACONS)

Underwater excavations, carried out by the Caesarea Ancient Harbor Excavation Project (CAHEP) in Israel in the 1980s and by the Combined Caesarea Expeditions in the 1990s, revealed numerous concrete blocks ([Area F blocks](#)) at various points in the massive ruins of the now submerged harbour ([harbour plan](#)), along with some well-preserved wooden formwork ([Area G forms](#)). They were major structural elements of the two breakwaters King Herod constructed during the years 23 to 10/9 BC to define the harbour that served his principal Mediterranean port city. John P. Oleson and Robert L. Hohlfelder (University of Contribution to the Colorado at Boulder) were co-directors of this underwater excavation project, together with Prof. Avner Raban (Haifa University).

An analysis conducted by John P. Oleson and Graham Branton (University of Victoria) of samples of hydraulic concrete ([mortar sample](#)) recovered from one such building block (c.15 x 11.5 x 2m) from the North Breakwater produced striking and unexpected results. The tuff and pozzolana ([tuff sample](#)) contained in the sample had come from the Bay of Naples. These ingredients were the basis of a distinct type of Roman hydraulic concrete that could set while in contact with salt or fresh water. An enormous quantity of the raw material had been transported 1200 miles as bulk cargo on merchant vessels to the site of King Herod's port, an undertaking of extraordinary magnitude and complexity. Continued excavation of these blocks by Avner Raban and Chris Brandon (Pringle-Brandon Architects, London) has revealed evidence of the strikingly complex floating and submersible formwork into which this concrete was poured ([barge-form being loaded](#)). Was this block of concrete with a clear geological fingerprint pointing to the Bay of Naples

an anomaly? Is it possible that all the raw material for the numerous concrete blocks and structures found at Caesarea were imported from Italy, or were appropriate local substitutes discovered and used? Did the basic mix of hydraulic concrete, first reported by Vitruvius c. 25 BC, change over time? How did the techniques of designing and deploying formwork and placing the concrete evolve over time? Can we see uniformity in composition of the concrete and design of formwork that might attest the activities of imperial architects following prescribed, standard procedures?

In order to answer some of these questions, in 2001 Oleson, Chris Brandon (architect, London) and Robert L. Hohlfelder (University of Colorado at Boulder) formed the ROMACONS project. We have been collecting and analyzing large core samples of hydraulic concrete taken from Roman submerged harbour sites and shoreline structures such as fish tanks around the Mediterranean basin. We plan to amass a large, geographically and chronologically diverse database that will serve as the beginning of the first comprehensive catalogue of hydraulic concrete used in Roman marine structures. Some specific goals of our investigations are:

1. To analyse the concrete matrix of our samples to determine size, material, and proportions of micro and macro aggregate.
2. To identify the sources of pozzolana, tuff, and other aggregate used in the concrete structures studies.
3. To compare the relative compressive strength and density of various concrete mixes.
4. To determine the sequence and pattern of laying the concrete materials and aggregates and thus to reconstruct the delivery systems used to move and hold the concrete in position on the ocean floor while it cured.
5. To assess the logistical systems employed for transport of massive quantities of raw material.
6. To determine any compositional variations in the concrete samples collected from different geographical regions or chronological periods.
7. Where feasible, to compare cores from maritime structures with those from terrestrial structures at the same site to determine whether special formulas were used for the maritime construction.
8. Finally, to investigate the practical challenges of building with hydraulic concrete through recreation of formwork and a *pila* in the sea with Roman type materials and procedures.

The team is uniquely qualified for this groundbreaking project. Oleson and Hohlfelder co-directed excavations at Caesarea from 1981-1985 and 1981-1990, respectively, and they both published extensively on the concrete and harbour design of King Herod's port. Oleson has published widely on ancient technology. Brandon has been one of the principal scholars studying hydraulic concrete found at Caesarea in the 1990s. He has also developed the methodology for drilling and recovering cores. The CTG Italcementi Group (<http://www.italcementi-group.com/newsite>) generously supplied the appropriate industrial concrete coring equipment for our use, and has agreed to carry out some analyses in their laboratories. The analyses have been carried out by Dr. Emanuele Gotti, L. Bottalico, and R. Cucitore at the Italcementi laboratory in Bergamo.

At the start we identified numerous target sites in Greece, Turkey, France, Spain, Algeria, Tunisia, Libya, and Israel. The first phase of the project consisted of the investigation of the concrete at a number of Roman harbours in Italy. In March 2001, the ROMACONS team carried out reconnaissance at Cosa and numerous other sites where hydraulic concrete was extensively used (e.g. Portus, Antium, Puteoli,

Astura, Terracina, Ponza, Egnazia, Baia, Misenum, etc.), to plan for future seasons of field work collecting samples. We also held discussions with Italian archaeologists whose research interests are relevant to our project (e.g., E. Felici and P. Gianfrotta), and we explored sources of tuff and pozzolana throughout Italy and collected samples of these materials. In August 2002 we began our field work by taking six cores from Claudian and Trajanic harbour structures at Portus, and the Neronian breakwater at Anzio (see preliminary reports of all our field season on this site). Subsequent campaigns were carried out at Cosa and Santa Liberata in 2003, Santa Liberata in 2004, Caesarea in Israel in 2005, Baia and Portus Iulius in 2006, Alexandria in Egypt and Chersonissos in Greece in 2007, and at Egnazia in 2008. In 2004 the team constructed a reproduction pila in the harbour of Brindisi with Vitruvian type concrete. During the three years since construction, we have taken cores from this pila at 6 month intervals.

We are in the process of obtaining permits to core at other important Roman harbour sites. We hope to complete the collection phase of our work in 2010 and begin the final analysis and publication of our data.

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## **The Roman Maritime Concrete Study (ROMACONS):**

### **Research at the Roman Harbour of Chersonisos in Crete, 2001 and 2007**

Chris Brandon (Architect, London), Robert L. Hohlfelder (University of Colorado), John Peter Oleson (University of Victoria), and Charles Stern (University of Colorado)

#### **Abstract**

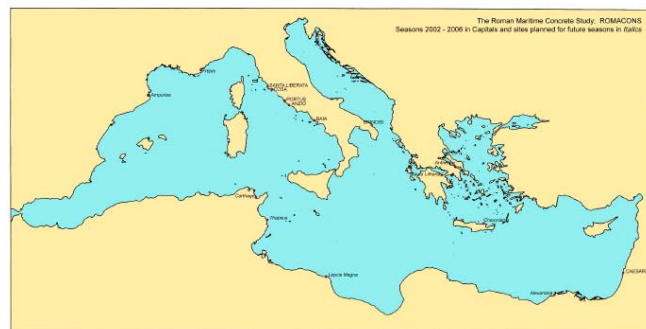
Vitruvius stated that it was necessary to use pozzolana from the Naples region in Italy to make hydraulic concrete that could set underwater. How extensive was the use of this particular material? We know that pozzolana was shipped across the Mediterranean from Italy to Israel for the construction of the major harbour of Caesarea. But did the Romans also export it to minor cities such as Chersonisos in Crete to build the concrete moles for its harbour? The Roman Maritime Concrete Study (ROMACONS) was established to answer these questions and others related to the use by the Romans of this extraordinary technology. This article reports on field research in 2001 and 2007, along with follow-up analysis in a laboratory.

#### **Introduction: The Roman harbour of Chersonisos in Crete and its Italian connection**

Sometime between 30 and 20 BC Marcus Vitruvius Pollio wrote a treatise on architecture in which he explains how harbours should be built at sites where there is no natural shelter (*De architectura* 5.12.1-7). He described how to construct underwater concrete foundations and structures that would form the artificial enclosing arms for harbours. Pre-Roman solutions generally included rubble or ashlar block breakwaters and moles. Although these methods continued to be used throughout the Roman era, another technique was introduced that revolutionized the design of harbour and other maritime structures – the use of hydraulic concrete. This material, which could be cast and set underwater, began to be used in harbour structures sometime in the second century BC (Gazda 2002; Oleson 1988; Oleson et al. 2004, 2006). Roman architects and engineers were free to create structures in the sea or along shorelines that previously would have been difficult or impossible to achieve. The active ingredient that reacted with the lime to form the hydraulic variant was pozzolana, a volcanic ash from the Campi Flegrei at the north end of the Bay of Naples, and made what we now call a pozzolanic concrete or mortar. Probably by accident, Roman builders found that when volcanic ash sand from quarries around the Bay of Pozzuoli was mixed with lime it made a stiff mortar that could be laid and cured underwater. Contained within formwork and laid in layers with large lumps of stone or tuff aggregate, it would set into a solid mass that has proved to resist the ravages of the sea for over two thousand years. Unlike lime mortars made with hydrated lime and inert siliceous sands that react with carbon dioxide in the air to reform into "man-made" limestone, pozzolanic mortars are

made with a highly reactive aluminosilicate component (pumice and volcanic ash) that when mixed with lime generates reaction products that take the form of gels; rods; fibres and plates that give strength and bind all the materials together (Lechtman and Hobbs 1987). Roman builders usually made lime that was free of impurities, such as clay, and it was consequently non-hydraulic.

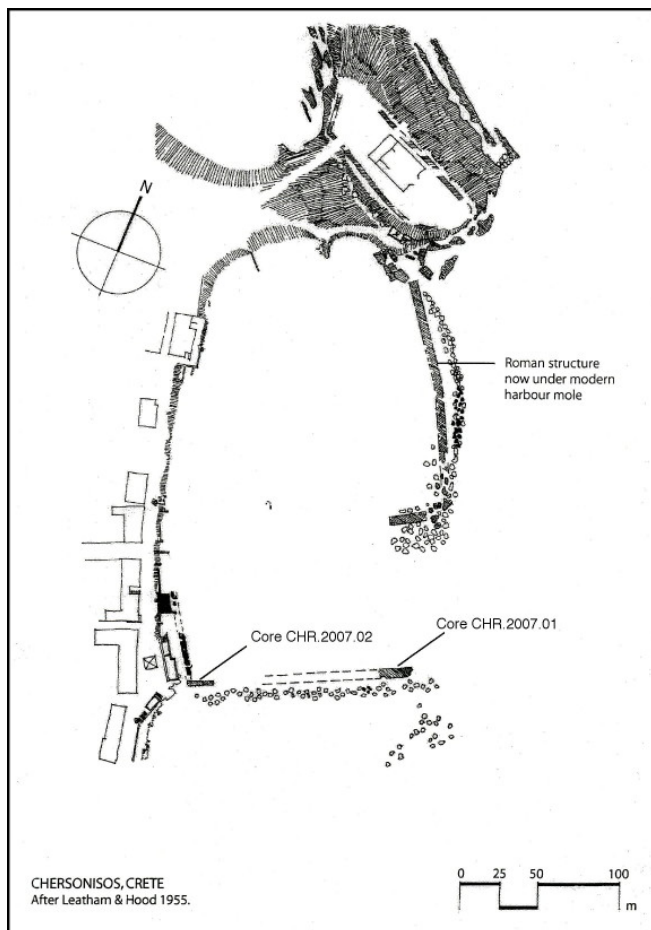
Vitruvius recommends that when building structures of concrete in the sea, the pozzolanic material should ideally be taken from around the Bay of Pozzuoli. We now know that the Romans were prepared to transport and ship this material for thousands of kilometres in order to ensure that they could use this technology. In 1991, chemical analysis carried out by Oleson and Branton on the pozzolana used in the concrete at the late first century BC Roman harbour of Caesarea Palaestinae found that it had been shipped in bulk freighters 2000 km from the Bay of Naples (Oleson and Branton 1992). The only known shipwreck that carried a secondary cargo of pozzolana from the Naples area was the large Roman merchant vessel that sank around 75-60 BC off the harbour of Madrague de Giens in the South of France (personal communication, Patrice Pomey). How widespread was this trade and the use of Vesuvian ash-based pozzolanic hydraulic concrete? To answer this and other questions that relate to the nature of the concrete used by the Romans in maritime structures, whether harbour moles, jetties, bridge footings or fishponds, the authors established ROMACONS: The Roman Maritime Concrete Project. Our database of known sites is extensive, spreading across the whole Mediterranean, and ranges in date from the second century BC to the Byzantine era. In addition to collecting small samples, between 2002 and 2008 we have collected 33 large cores (9 cm in diameter and up to 5.8 m long) from 32 sites in Italy, Israel, Egypt, and Greece, using a hydraulically driven coring device with diamond bit (Hohlfelder 2008; Hohlfelder et al. 2005; Oleson et al. 2004, 2006). (Figure 1: map of sites cored).



One of the first harbours investigated was the Roman harbour at Chersonisos (Limin Khersonisou) on the northern coast of Crete. This minor Roman harbour (270 x 150 m in size) was founded on a small Hellenistic haven that was sited in the lee of a headland called Kastri. The Roman improvements to the Hellenistic harbour consisted of the addition of concrete moles to the rubble breakwaters to the south and east, and concrete quays along the shore (Figure 2: plan of harbour, after Leatham and Hood 1958-59).

We knew that the Romans were prepared to ship vast quantities of pozzolana and tuff across the Mediterranean from Italy to Caesarea in what is now Israel. But did they also export it for use in the construction of smaller provincial harbours such as Chersonisos? In 1955 and 1956 the ancient harbour of Chersonisos was surveyed by John Leatham and Sinclair Hood (Leatham and Hood 1958-59). Since then, a new harbour and the resort of Limin Khersonisou have developed and the majority of the Roman moles are buried under the modern marina. However, the mole to the south and the quay on the west are untouched and were the source of the samples taken in October 2001 and September 2007.





The southern mole is preserved for a length of 22.7 m in two parts and stands within 3.3 m of water to just below sea level. Concrete quays extend along the shoreline on the west of the harbour and remain in evidence for a length of 30 m and approximately 2.6 m wide. The long "L" shaped eastern mole that now lies hidden under the modern concrete breakwater was originally 150 m long with a 30 m long return and between 5.2 to 5.3 m wide. Leatham and Hood described it as being well preserved and faced with small squared blocks of stone that remained in-situ at the level of the seabed. Along the inner surface of the mole were recorded a series of vertical recesses set at 6.8 m centres alternately 1.0 m and 1.5 m deep and between 0.6 to 0.8 m wide. These were initially thought to have been either recesses that housed wooden steps or timber fenders. It is more likely that these were the remains of the original formwork within which the concrete was cast. Was this an inundated structure where the mix of lime, pozzolana and aggregate was placed underwater, or was it a double-walled drained form that allowed an ordinary sand lime mortar and rubble fill to be placed within a stone-faced mole all built in a dry environment? The presence of pumice in a sand lime mortar does not necessarily mean that it was purposely made to be hydraulic. In Crete there is significant contamination of the soils from pumice and ash that originated at Santorini. If local sands were used in a conventional air-cured mortar, it would also have pozzolanic properties that would show up in analysis. The geological signature of any Santorini pumice or volcanic ash, however, would be distinctly different from pozzolana from Naples or elsewhere.

Leatham and Hood mentioned that the original top surface of the moles remained in only a few places and were almost flush with the current sea level. This change in relative level to the sea, together with the presence of drowned fishpond on the south eastern tip of the Kastri headland, indicates that the sea level has risen approximately 1 m since the Roman era. The harbour is now fairly shallow, with a maxi-

mum depth of 3m to a sandy bottom that has obviously silted up over the course of time.

In October 2001 a permit from the Ephorate of Underwater Antiquities and the Director of Conservation allowed us to take five samples 3 cm in diameter and 10 cm in length from the remains of the concrete moles. Chris Brandon carried out the sampling on 14 October 2001. The British School at Athens supported the application, and we are indebted to David Blackman, Director of the School at the time, for his guidance and assistance. We also thank Katerina Delaporta and Elpida Hadjidaki of the Ephorate of Underwater Antiquities without whose help we could not have carried out the work. Due to the limited time available and the restriction on the sample size, it was decided to collect them with steel tubes driven into the concrete matrix or mortar using a 2-kg lump hammer. Five 30-cm long hardened stainless steel coring tubes with an external diameter of 3.2 cm were individually driven into the moles at selected sites. The samples of mortar within the tubes were retained for later removal on shore and sent for analysis at the University of Colorado. The mortar samples were analysed by Charles Stern of the Department of Geological Sciences, University of Colorado, Boulder. The ratio of mortar to aggregate was much lower than at the other sites that had been studied. Preliminary measurements indicate the intervals among the large aggregate at Chersonisos average approximately 4 cm, whereas at Nero's harbour of Antium (Anzio) it is 7.9 cm, at the Claudian harbour of Portus 11.9 cm, and at the Trajanic harbour of Portus 4.7 cm. This meant it was difficult to find locations on the surface of the marine encrusted remains where there was a sufficient quantity of mortar that could be sampled with the hammer driven corer. In the end only fragmentary samples were collected, confirming the inadequacy of this method of surface collecting concrete samples.

Microscopic examination and petrographic analyses of two thin sections cut from the light grey white mortar from a sample taken from the western end of the southern mole (CHR.2001.02), showed that 50 percent of the sample consisted of a fine grained matrix of mortar. The mortar contained aggregate clasts of the following materials:

- Grey and yellow pumice fragments ranging between 1 and 10 mm in diameter for 30% of the volume of the sample. Pumice consisted of clear and colourless to pale brown glass and contained crystals of feldspars, biotite, and green clinopyroxene, and vesicles that vary between rounded to highly elongated
- Grey, red and black volcanic rock and individual crystal fragments ranging between 1 and 4 mm in diameter for 10 % of the volume of the sample. Rock fragments include both light coloured felsic and red and black mafic igneous rocks. Crystal fragments include quartz, plagioclase, biotite and green clinopyroxene, all also found as crystals in either pumice and rock fragments.
- White calcite and lime fragments ranging between 1 and 10 mm in diameter for 10 % of the volume of the sample.

The other samples of mortar had a similar composition, and it was established that it was representative of all the concrete used at Chersonisos.

A pumice separate was extracted by hand from the consolidated sample CHR.2001.02 and analysed for chemical composition. It appears that the pumice ash contained within the mortar has much in common with volcanic material from Italy, for example a very high K<sub>2</sub>O content (>6 wt %) and total alkali element concentration (Na<sub>2</sub>O + K<sub>2</sub>O > 10 wt %) for a rock with an intermediate silica concentration (SiO<sub>2</sub> = 60 wt %). This pumice did not derive from the island of Santorini to the north, which typically would have



lower K<sub>2</sub>O (<3 wt %) and total alkali concentration (<8 wt %) even for pumice with very high silica concentration (SiO<sub>2</sub>>70 wt %). Although it may possibly have come from the island of Kos or even Southwest Turkey, where highly alkaline volcanic rocks also occur, it more probably was sourced from Italy.

The restrictions imposed on surface collected samples severely limited the range of analysis that could be carried out. It was also apparent that Roman concrete was not homogeneous and surface samples were unlikely to be truly representative of the whole.

In September 2007 a larger team including C. Brandon, J. P. Oleson, and D. Klapceki returned to Chersonisos. With the kind assistance of Mr. Tolis Vougioukas, we arranged for the rental of a small boat and boat tender to carry our coring equipment (Figure 3, boat with equipment).



With the diligent assistance of the Director of the 23<sup>rd</sup> Ephorate of Prehistoric and Classical Antiquities in Heraklion Ms. Maria Bredaki, we arranged for Ms. Eirini Karousou to observe our field work on 11 and 12 September. The weather and sea conditions were excellent, and two cores were recovered from the Roman period breakwater in the harbour basin (Figure 1, plan of harbour). After removal of the cores, the coring holes were filled with local sand to within 10 cm of the surface of each block. The remainder of each hole was then filled with a mortar composed of the same materials as the ancient block: lime and pozzolana. (Figure 4: Boat and coring equipment at CHR.2007.01)



## Preliminary Description of the 2007 Cores:

### CHR.2007.01.

Location: pila in water, second from the end of the mole on the east side of harbour, central northern portion. UTM 353943 E 3909741 N.

Water depth: 0.70 m.

Depth of core hole: 1.90 m; the base of the wall was not reached

Size of recovered core: 1.2 m, all fragmentary; no section longer than 0.12 m.

Comments: The mortar was very crumbly, so only small portions survived the coring process. The poor cohesion between the mortar and the aggregate allowed much of the core to grind itself away. The longest intact mortar section was 0.10 m long. The mortar seems very open and degraded. Possibly it was low in lime, either because of a poor mix, or from loss through chemical action or erosion. The mortar and aggregate both appear to be poorly sorted and poorly mixed, including fairly large chunks of tuff (up to D 0.028 m), large voids where a crumbly black mineral has fallen out (D 0.016 m, 0.014 m), and aggregations of lime nodules (D 0.002-0.004 m).

### CHR.2007.02

Location: quay wall near south shore of harbour, exposed above waterline. UTM 353835 E 3909705 N.

Depth of core hole: 1.52 m; the base of the wall was reached.

Size of recovered core: 1.49 m, in several sections; the longest section is 0.20 m. There was a small amount of grinding between 2 sections. (Figure 5: CHR.2007.02)



Comments: The mortar seems very porous and granular, perhaps poor in lime. The lime nodules range in size from 0.004-0.025m, although mostly smaller. In addition to possibly being short of lime, it is probable that this mortar was not compacted; it simply looks very loose. There are small pieces of tuff, ranging from 0.005-0.035 m, predominantly in the middle of this range. The *kurkar* aggregate is very irregular in size and shape, and irregular in distribution, from D 0.05 to D >0.18 m. It constitutes approximately 40% of the core.

The cores are at present awaiting chemical and structural analysis at the Italcementi laboratory in Bergamo.

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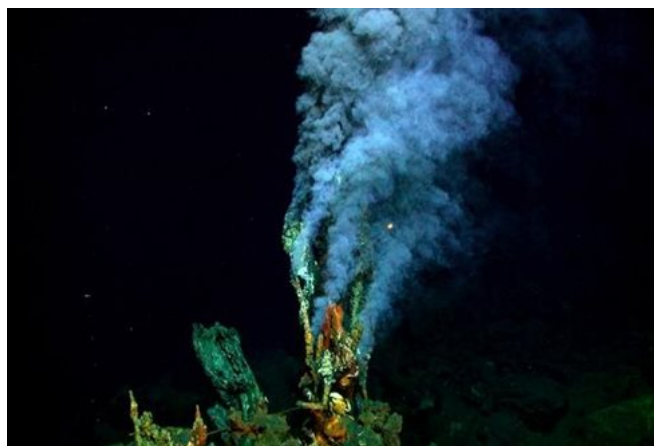
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### Χρυσάφι στην άβυσσο Πράσινο φως για το πρώτο ορυχείο στο βυθό



Πολύτιμα μέταλλα αναβλύζουν από ηφαιστειογενείς οπές στο βυθό που ονομάζονται υδροθερμικά φρεάτια

Καναδική εταιρεία κατέληξε σε συμφωνία με την κυβέρνηση της Παπούα Νέας Γουινέας για την εξόρυξη μετάλλων από το βυθό του Ειρηνικού Ωκεανού -ένα φιλόδοξο εγχείρημα

που κατέστη εφικτό χάρη σε τεχνολογίες που αναπτύχθηκαν για τις υπεράκτιες γεωτρήσεις υδρογονανθράκων.

Η εξορυκτική Nautilus Minerals έχει ήδη κατασκευάζει ένα γιγάντιο μηχάνημα των 340 τόνων που θα θρυμματίζει αποθέσεις μετάλλων στο βυθό, σε βάθος 1.500 μέτρων, προκειμένου να αντληθούν στη συνέχεια σε πλοία υπό τη μορφή λάσπης. Οι αποθέσεις καταλαμβάνουν έκταση όσο 10 γήπεδα ποδοσφαίρου και είναι εξαιρετικά πλούσιες σε χαλκό, χρυσό και άλλα μέταλλα.

Η νησιωτική Παπούα Νέα Γουινέα βρίσκεται πάνω στο Λεγόμενο Δακτύλιο της Φωτιάς, μια σειρά ηφαιστειών που περικυκλώνουν τον Ειρηνικό και σημειώνουν τα όρια των τεκτονικών πλακών. Όπως συμβαίνει και σε άλλες σεισμογόνες περιοχές, η γεωλογική δραστηριότητα γύρω από το νησί της Νέας Γουινέας φέρνει πολύτιμα μεταλλεύματα κοντά στην επιφάνεια.

Το υποβρύχιο ορυχείο της Nautilus Minerals, με την ονομασία Solwara-1, θα εκμεταλλευτεί τα μέταλλα που αναβλύζουν από υδροθερμικά φρεάτια (οπές που κατεβαίνουν στο υπέδαφος) διαλυμένα σε υπέρθερμο, όξινο νερό. Το νερό αυτό ψύχεται απότομα καθώς συναντά το ψυχρό, αλκαλικό νερό του ωκεανού, οπότε τα διαλυμένα συστατικά του κατακρημνίζονται και δημιουργούν εκτεταμένες αποθέσεις.

Όπως **ανέφερε** στο BBC ο διευθύνων σύμβουλος της Nautilus Μάικ Τζόνσον, ένα θερμόμετρο που αφήθηκε στο βυθό για 18 μήνες διαπιστώθηκε ότι είχε καλυφθεί πλήρως από αποθέσεις χαλκού.

Τα υποβρύχια ορυχεία είναι ένα παλιό όνειρο της εξορυκτικής βιομηχανίας, μέχρι πρόσφατα όμως η υλοποίησή τους θεωρούνταν αδύνατη λόγω των τεχνικών δυσκολιών. Τα τελευταία χρόνια όμως οι επενδύσεις σε υπεράκτια κοιτάσματα υδρογονανθράκων οδήγησαν στην τελειοποίηση τεχνολογιών για βιομηχανικές δραστηριότητες σε μεγάλο βάθος.

Όμως το ατύχημα στην εξέδρα Deepwater Horizon της BP το 2010, που είχε ως αποτέλεσμα τη μεγαλύτερη διαρροή πετρελαίου στην αμερικανική ιστορία, κατέστησε σαφές ότι οι κίνδυνοι παραμένουν.

Δεν είναι λοιπόν περίεργο που οι περιβαλλοντικές οργανώσεις αντιδρούν στην αξιοποίηση των κοιτασμάτων του βυθού. «Οι ωκεανοί δεν έχουν ακόμα χαρτογραφηθεί πλήρως, οπότε ο κίνδυνος απώλειας χλωρίδας και πανίδας δεν είναι ακόμα κατανοητός» επισήμανε ο Ρίτσαρντ Πέιτζ της Greenpeace.

Η Nautilus, από την πλευρά της, διαβεβαιώνει ότι το οικοσύστημα των υδροθερμικών φρεατίων θα ανακάμψει 5 με 10 χρόνια μετά το κλείσιμο του ορυχείου στο μέλλον, καθώς τα ρεύματα θα φέρουν ασπόνδυλα και άλλα είδη από γειτονικά φρεάτια.

Χρειάστηκαν χρόνια διαπραγματεύσεων μέχρι να συμφωνήσουν η εταιρεία και η Παπούα Νέα Γουινέα για τους όρους λειτουργίας του ορυχείου. Η τελική συμφωνία προβλέπει ότι το δημόσιο θα αποκτήσει το 15% του ορυχείου για το ποσό των 120 εκατομμυρίων δολαρίων.

Υπάρχουν όμως κι άλλες χώρες που διερευνούν τη δυνατότητα υποβρύχιας εξόρυξης: Η Διεθνής Αρχή Βυθού (ISA), ο φορέας του ΟΗΕ που επιβλέπει αυτή τη δραστηριότητα, έχει δώσει μέχρι στιγμής 19 άδειες για έρευνες στο βυθό.

Η Ιαπωνία, για παράδειγμα, **ανακοίνωσε** πέρυσι ότι εντόπισε στο βυθό του Ειρηνικού εξαιρετικά πλούσια κοιτάσματα «σπάνιων γαιών» -μια σειρά σπάνιων στοιχείων που χρησιμοποιούνται ευρέως στη βιομηχανία.

(Newsroom ΔΟΛ / 25 Απρ. 2014, <http://news.in.gr/science-technology/article/?aid=1231313882&ref=newsletter>)



## Agreement reached on deep sea mining



The project will extract ores of copper, gold and other valuable metals from a depth of 1,500m

### Plans to open the world's first mine in the deep ocean have moved significantly closer to becoming reality.

A Canadian mining company has finalised an agreement with Papua New Guinea to start digging up an area of seabed.

The controversial project aims to extract ores of copper, gold and other valuable metals from a depth of 1,500m.

However, environmental campaigners say mining the ocean floor will prove devastating, causing lasting damage to marine life.

The company, Nautilus Minerals, has been [eyeing the seabed minerals](#) off Papua New Guinea (PNG) since the 1990s but then became locked in a lengthy dispute with the PNG government over the terms of the operation.

Under the agreement just reached, PNG will take a 15% stake in the mine by contributing \$120m towards the costs of the operation.

Mike Johnston, chief executive of Nautilus Minerals, told BBC News: "It's taken a long time but everybody is very happy."

"There's always been a lot of support for this project and it's very appealing that it will generate a significant amount of revenue in a region that wouldn't ordinarily expect that to happen."

The mine will target an area of hydrothermal vents where superheated, highly acidic water emerges from the seabed, where it encounters far colder and more alkaline seawater, forcing it to deposit high concentrations of minerals.



Construction of the largest machine - the 310-tonne Bulk Cutter - was completed in the UK

The result is that the seabed is formed of ores that are far richer in gold and copper than ores found on land.

Mr Johnston said that a temperature probe left in place for 18 months was found to have "high grade copper all over it".

For decades, the idea of mining these deposits - and mineral-rich nodules on the seabed - was dismissed as unfeasible because of the engineering challenge and high cost.

But the boom in offshore oil and gas operations in recent years has seen the development of a host of advanced deep sea technologies at a time when intense demand for valuable metals has pushed up global prices.

The mine, known as Solwara-1, will be excavated by a fleet of robotic machines steered from a ship at the surface.

The construction of the largest machine, a Bulk Cutter weighing 310 tonnes, has just been completed by an underwater specialist manufacturer, Soil Machine Dynamics (SMD), based in Newcastle, UK.

The plan is to break up the top layer of the seabed so that the ore can be pumped up as a slurry.

The agreement with PNG now clears the way for Nautilus to order a specialist vessel to manage the operation. Mining itself could start within five years.

Environmental campaigners have long argued that seabed mining will be hugely destructive and that the precise effects remain unknown.

Richard Page, oceans campaigner for Greenpeace, said: "The emerging threat of seabed mining is an urgent wake-up call for the need to protect the oceans."



For decades, the idea of mining these deposits was dismissed as unfeasible

"The deep ocean is not yet mapped or explored and so the potential loss of fauna and biospheres from mining is not yet understood."

"Only 3% of the oceans and only 1% of international waters are protected, which makes them some of the most vulnerable places on earth - what we desperately need is a global network of ocean sanctuaries."

According to Nautilus, the mine will have a minimal environmental footprint, covering the equivalent of about 10 football fields and focusing on an area which is likely to be rapidly re-colonised by marine life.

Mr Johnston said: "It's a resilient system and studies show that life will recover in 5-10 years. An active venting site 1km to the southeast has the same bugs and snails and the current will carry the bugs and snails to the mine site. We expect it to recover quite quickly."



But this will be the first attempt to extract ore from the ocean floor, so the operation - and the company's assurances about the impacts - will be watched closely.

So far, 19 licences to search for seabed minerals have been awarded by the International Seabed Authority, the UN body policing this emerging industry.

The International Seabed Authority (ISA), which has welcomed the Nautilus Minerals agreement with Papua New Guinea, is currently drawing up guidelines for the environmental management of future seabed mining.

Michael Lodge of the ISA told the BBC: "This is a very exciting opportunity and we are looking forward to learning from the tests of the new machine, which is a world first and should give us some valuable insights into technical feasibility and environmental impact."

(David Shukman, Science editor / BBC, 25 April 2014, <http://www.bbc.com/news/science-environment-27158883>)



### **Ανακαλύφθηκε τυχαία νέα κατηγορία ανακυκλώσιμων υλικών**

**Ερευνητές ανακάλυψαν -και μάλιστα τυχαία- μια νέα κατηγορία συνθετικών πολυμερών υλικών, από τα οποία μπορεί να δημιουργηθεί μια νέα γενιά ανακυκλώσιμων βιομηχανικών θερμοπλαστικών.**

Η ανακάλυψη μπορεί μελλοντικά να βρει σημαντικές εφαρμογές σε τομείς όπως οι μεταφορές, η αεροδιαστημική και η μικροηλεκτρονική.

Οι επιστήμονες έκαναν τη σχετική δημοσίευση στο περιοδικό «Σάιενς», σύμφωνα με το BBC και τους «Τάιμς της Νέας Υόρκης».

Η νέα κατηγορία υλικών περιλαμβάνει αφενός δυνατά και άκαμπτα πλαστικά, αφετέρου εύκαμπτα τζελ, που προσαρμόζονται ανάλογα με τις ανάγκες της χρήσης τους.

Η ανακάλυψη μπορεί να οδηγήσει σε φθηνότερα και πιο φιλικά στο περιβάλλον αυτοκίνητα, αεροπλάνα και ηλεκτρονικά (ημιαγωγούς κ.ά.).

Είναι η πρώτη φορά που θερμοσκληρυνόμενα πλαστικά (thermoset) είναι δυνατό να παραχθούν σε ανακυκλώσιμη μορφή. Μέχρι σήμερα αυτά τα υλικά ήταν μη ανακυκλώσιμα, όπως μετέδωσε το Αθηναϊκό Πρακτορείο.

Όπως έχει συμβεί συχνά στην ιστορία της επιστήμης, η ανακάλυψη έγινε με τυχαίο τρόπο στα εργαστήρια της εταιρείας στο Σαν Χοσέ της Καλιφόρνια, όταν η χημικός ξέχασε να προσθέσει ένα συστατικό σε μια χημική αντίδραση που πραγματοποιούσε πειραματικά.

Προέκυψε έτσι ένα νέου τύπου λευκό πλαστικό και, όπως δήλωσε η ίδια χαρακτηριστικά, «δεν ήξερα τι ήταν αυτό το πράγμα. Έπρεπε να σπάσω τη σφαιρική εργαστηριακή φιάλη με ένα σφυρί για να το βγάλω έξω».

Εξίσου τυχαία είχε ανακαλυφτεί, το 1938, το «τεφλόν» από τον χημικό Ρόι Πλάνκετ της εταιρείας DuPont.

Το νέο πολυμερές υλικό αποδείχτηκε τρομερά σκληρό και σταθερό. Επιπλέον, με την κατάλληλη επεξεργασία με οξύ, είναι δυνατό να επανέλθει στα αρχικά χημικά συστατικά του (μονομερή), έτσι ώστε αυτά να ανακυκλωθούν σε κάποια νέα χρήση.

Τα πολυμερή χαρακτηρίζονται από πολύπλοκες μακριές αλυσίδες μικρότερων και απλούστερων μορίων, συνδεδεμένων μεταξύ τους με χημικούς δεσμούς.

Είναι πανταχού παρόντα στην καθημερινή ζωή μας, στα ρούχα και τις φιάλες (πολυεστέρες), στα χρώματα (πολυακριλικά), στα πλαστικά μπουκάλια (πολυαιθυλένιο), στις συσκευασίες τροφίμων (πολυστυρένιο κ.ά.), στα εξαρτήματα αυτοκινήτων και αεροπλάνων (πολυαμίδια, πολυιμίδια κ.ά.). Όπως είπε ο ερευνητής, «ζούμε στην εποχή των πολυμερών».

Αν και παραλλαγές των υπαρχόντων πολυμερών ανακαλύπτονται κατά καιρούς, τα νέα ανακυκλώσιμα θερμοπλαστικά θεωρούνται η πρώτη σημαντική νέα «οικογένεια» πολυμερών, που έχει ανακαλυφτεί εδώ και τουλάχιστον δύο δεκαετίες.

Είναι η πρώτη στον κόσμο κατηγορία υλικών, που είναι πιο δυνατά από τα οστά και, ταυτόχρονα, πλήρως ανακυκλώσιμα.

Επειδή είναι ανθεκτικά και ελαφριά, τα υφιστάμενα θερμοπλαστικά χρησιμοποιούνται στα σύγχρονα αυτοκίνητα και αεροπλάνα, συχνά σε ανάμιξη με νανοσωλήνες άνθρακα, ώστε να σχηματιστούν άλλα σύνθετα υλικά, που είναι έως 50% πιο ανθεκτικά και έχουν ιδιότητες παρεμφερείς με εκείνες των μετάλλων, αλλά με το συγκριτικό πλεονέκτημα του μικρότερου βάρους. Περίπου το 50% του νέου αεροσκάφους Airbus A350 θα κατασκευαστεί από τέτοια υλικά.

Μέχρι τώρα όμως, κανένα από αυτά τα θερμοπλαστικά δεν ήταν δυνατό να ανακυκλωθεί μετά τη θερμική επεξεργασία που είχε υποστεί.

Η νέα ανακάλυψη χαιρετίστηκε ως σημαντική, καθώς πλέον, όταν ένα τέτοιο ακριβό συνθετικό υλικό καταστραφεί ή ολοκληρώσει τον κύκλο της ζωής του, θα μπορεί να επισκευάζεται επιτόπου ή να ανακυκλώνεται, αντί να πετιέται στις χωματερές ή στις θάλασσες - με ό,τι αυτό συνεπάγεται για την επιβάρυνση του περιβάλλοντος και την αύξηση του κόστους παραγωγής.

Οι ερευνητές αισιοδοξούν ότι, πέρα από το όφελος της ανακύκλωσης, θα βρουν σταδιακά και νέες καινοτομικές εφαρμογές του νέου υλικού. «Κάθε φορά που ανακαλύπτεται μια νέα χημική αντίδραση που δημιουργεί πολυμερή, αυτό οδηγεί σε όλων των ειδών τα νέα υλικά», τόνισε ο Αμερικανός ερευνητής.

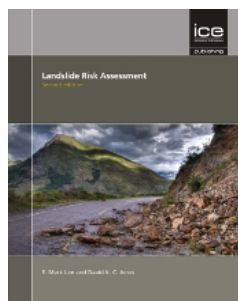
Ήδη, οι επιστήμονες προσάρμοσαν κατάλληλα τη διαδικασία, χρησιμοποιώντας διαφορετικά μονομερή ως συστατικά, για να παράγουν πλέον όχι ένα σκληρό θερμοπλαστικό, αλλά μία εύκαμπτη ελαστική γέλη (τζελ), που μπορεί να αυτοεπιδιορθώνεται, δηλαδή να επανέρχεται μόνο της στην αρχική κατάστασή της, όταν υποστεί κάποια ρωγμή.

Ένα τέτοιο εύπλαστο υλικό μπορεί μελλοντικά να αξιοποιηθεί από τη βιομηχανία καλλυντικών, τη βιομηχανία χρωμάτων, τη φαρμακοβιομηχανία κ.ά.

Προσωρινά, τα νέα υλικά έχουν ονομαστεί «Titan» (το σκληρό) και «Hydro» (το εύκαμπτο). Δεν είναι ακόμη έτοιμα για εμπορική χρήση, αλλά κάτι τέτοιο είναι απλώς θέμα χρόνου.

(ΚΕΡΔΟΣ online / 16.05.2014)

# ΝΕΕΣ ΕΚΔΟΣΕΙΣ ΣΤΙΣ ΓΕΩΤΕΧΝΙΚΕΣ ΕΠΙΣΤΗΜΕΣ



## **Landslide Risk Assessment 2nd edition**

**E. Mark Lee and David K.C. Jones**

London School of Economics, UK

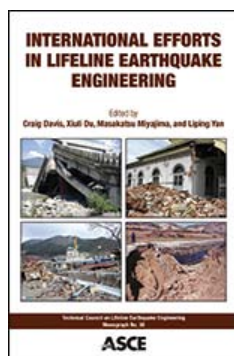
*Landslide Risk Assessment* provides guidance to practitioners on establishing the likelihood and extent to which future slope failures could adversely impact society and affect people and property.

The only book to focus on risk and landslides, using examples from across the globe, *Landslide Risk Assessment* examines a variety of approaches to landslide risk assessment and management, introducing the key challenges that practitioners will need to overcome: estimating the probability and consequences of landsliding, combining these to develop a measure of the risk, and making the transition between risk assessment and risk management.

### **Contents**

- Preface
- Background to landslide risk assessment
- The Basic Elements of Landslide Risk Assessment
- Landslide hazard
- Qualitative and semi-quantitative risk assessment
- Introduction to Probability and Quantitative Assessment
- Estimating the probability of landsliding
- Exposure
- Vulnerability
- Estimating the consequences
- Quantifying risk
- From risk estimation to landslide management strategy
- Future Challenges
- Glossary of terms
- References

(ICE Publishing, 13.12.2013)



## **International Efforts in Lifeline Earthquake Engineering**

**Davis, C., Du, X., Miyajima, M.  
and Yan, L. (Editors)**

### **TCLEE Monographs TCLEE 38**

Proceedings of the Sixth China-Japan-U.S. Trilateral Symposium on Lifeline Earthquake

Engineering, held in Chengdu, China, May 28–June 1, 2013. Sponsored by Beijing University of Technology, China; Kanazawa University, Japan; University of Southern California, U.S.A.; Southwest Jiaotong University, China; Shanghai Institute of Disaster Prevention and Relief, China; Research Institute of Lifeline Engineering, Inc., Japan; Lifeline Network, Kansai (LiNK), Japan; American Society of Civil Engineers Technical Council on Lifeline Earthquake Engineering (TCLEE), U.S.A.; International Association of Chinese Geotechnical Engineers (IACGE), U.S.A.; and the National Natural Science Foundation of China.

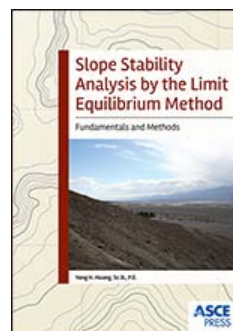
This TCLEE Monograph contains 86 peer-reviewed papers covering recent developments in lifeline earthquake engineering involving water, wastewater, gas and liquid fuels, electrical power, telecommunications, and transportation systems.

Topics include:

- seismicity, ground motions, and site effects
- seismic performance, modeling, evaluation, and design of infrastructure systems
- seismic reliability and post-earthquake serviceability
- recovery and resilience of lifeline systems
- hospitals
- lifeline interactions
- fire following earthquake
- tunnels and underground structures
- geotechnical and structural earthquake behavior related to lifelines
- seismic testing and analysis for lifelines

TCLEE 38 will be of interest to practitioners, researchers, and students interested in international approaches to seismic resilience.

(ASCE Press, 2014)



## **Slope Stability Analysis by the Limit Equilibrium Method Fundamentals and Methods**

**Yang H. Huang**

*Slope Stability Analysis by the Limit Equilibrium Method: Fundamentals and Methods* presents basic principles for the safe design of constructed or natural earth slopes.

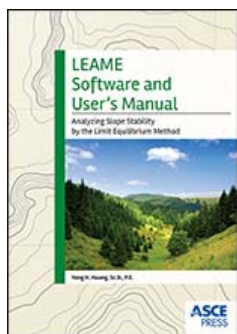
The limit equilibrium method is the most common approach for analyzing slope stability in both two and three dimensions. This method identifies potential failure mechanisms and derives factors of safety for a particular geotechnical situation. It is an appropriate choice for assessing the stability of retaining walls, shallow and deep foundations, earth and rock dams, surface mining sites, and potential landslides.

The fundamentals of slope stability encompass slope movements and methods for stability analysis, mechanics of slope failure and factors of safety, laboratory and field methods to determine the shear strength of soils, estimation of phreatic surfaces, and remedial measures for correcting slides. Methods of stability analysis cover simple formulas for determining the factor of safety for plane failures, stability charts, methods of slices for two-dimensional analysis, three-dimensional analysis techniques, and reliability of slope design.

An appendix provides a preview of a companion product, *LEAME Software and User's Manual: Analyzing Slope Stability by the Limit Equilibrium Method*, a computer program for performing the slope stability analysis presented in this work.

The clear presentation of the principles of slope stability analysis ensures that this work will be a frequently consulted reference for practicing engineers. The wealth of worked examples and problem sets make this a suitable textbook for senior and graduate students in soil mechanics and geotechnical engineering.

(ASCE Press, 2014)



### **LEAME Software and User's Manual**

#### **Analyzing Slope Stability by the Limit Equilibrium Method**

**Yang H. Huang**

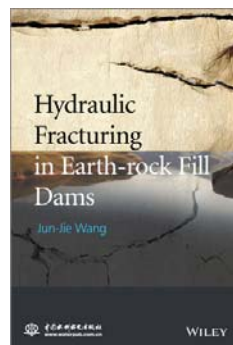
*LEAME Software and User's Manual: Analyzing Slope Stability by the Limit Equilibrium Method* provides a PC-based software program for performing slope stability analyses, along with supporting documentation. LEAME (limit equilibrium analysis of multilayered earthworks) is the most recent version of software, previously known as REAME (rotational equilibrium analysis in multilayered embankments). Developed by Yang H. Huang at the University of Kentucky and thoroughly tested in both engineering firms and classrooms, LEAME determines the factors of safety for both two- and three-dimensional slopes and contains many new features not available elsewhere to solve practical problems in slope stability.

The software is accompanied by a PDF user's manual with detailed instructions for installing and operating LEAME. The manual explains the input parameters in each data entry form. It also describes the features available for two- and three-dimensional analysis, illustrated with sample problems and worked examples. Data files for the examples are also included. The application of LEAME to problems of spoil and waste disposal in surface mining is covered in detail, including worked examples.

The software and user's manual are offered in conjunction with a companion volume, *Slope Stability Analysis by the Limit Equilibrium Method: Fundamentals and Methods*, which presents principles and methods for using the limit equilibrium method in analyzing slopes. In combination, the book, software, and user's manual provide practicing engineers, engineering professors, and students with a complete set of tools for understanding and analyzing challenges in slope stability.

The LEAME software can be used on any PC with Windows 95 or higher. It is not available for other operating systems. Software is supplied under a license that restricts usage to a single computer. Multi-user/multisite licenses are available by inquiring at [ascelibrary@asce.org](mailto:ascelibrary@asce.org) or calling 1-800-548-2723.

(ASCE Press, 2014)



### **Hydraulic Fracturing in Earth-rock Fill Dam**

**Jun-Jie Wang**

Presents a systematic and comprehensive study of hydraulic fracturing, original in its concentration of core soil problems

There have been a number of well-studied cases in which dams have failed or been damaged by concentrated leaks for no apparent cause. In some of these experiences, investigators concluded that differential settlement cracks were the probable causes, even though no cracks were seen on the surface. In these examples, it was not determined whether the crack was open before the reservoir filled or whether it might have opened afterward. In several unsolved problems on the safety of the earth-rock fill dam, the problem of hydraulic fracture in the soil core of the earth-rock fill dam is one that is widely paid attention by designers and researchers. Hydraulic fracturing is generally considered as a key cause which may induce the leakage of the dam during first filling.

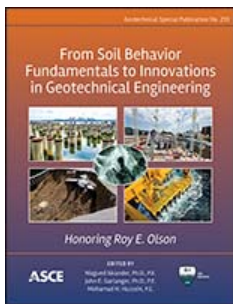
In this extensive book, a new numerical simulate method is suggested. The method is based on the conventional two-dimensional finite element technique, and the theoretical formulations to calculate energy release rate using virtual crack extension method. The influence factors on convergence of calculated J integral are investigated. The accuracy of the calculated J integral is verified by analysing the three typical problems in Fracture Mechanics, in which propagation of crack may follow mode I, mode II and mixed mode I-II respectively. Using the new numerical method, the factors affecting the occurrence of hydraulic fracturing in the earth-rock fill dam are investigated. The investigating results indicate that increasing any of the Young's modulus, the Poisson's ratio and the density of the core soil is helpful to reduce the likelihood of the occurrence of hydraulic fracturing. The likelihood of the occurrence of hydraulic fracturing increases with increasing the water level or the crack depth. The lower part of the dam core is the zone in which the phenomenon of hydraulic fracturing may be induced easily. As an example to analyse the ability of earth-rock fill dam to resist hydraulic fracturing, the Nuozechadu Dam located in Western China is analysed.

- Presents a systematic and comprehensive study of hydraulic fracturing, original in its concentration of core soil problems
- Focuses on the problem of hydraulic fracturing in earth-rock fill dams from three aspects; conditions and mechanisms of hydraulic fracturing, criterion of hydraulic fracturing, and numerical method on hydraulic fracturing
- Examines advanced laboratory soil testing, application of numerical methods and field testing/monitoring, all needed for a better understanding of hydraulic fracturing in earth/rock fill dams
- Provides an essential reference in an area of scarce research in this field, and the need in high earth dam construction in developing countries is pressing

Ideal for researchers in Hydraulic and Geotechnical Engineering Fields; Students on Masters or PhD courses; as well as Designers and Constructors in Hydraulic and Geotechnical Engineering Fields.

(WILEY, April 2014)





## From Soil Behavior Fundamentals to Innovations in Geotechnical Engineering

Honoring Roy E. Olson

**M. Iskander, J. Garlanger and M. H. Hussein, Editors**

### Geotechnical Special Publications (GSP) GSP 233

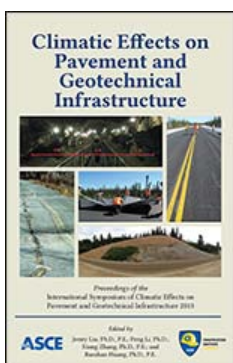
Sponsored by the Geo-Institute of ASCE.

*From Soil Behavior Fundamentals to Innovations in Geotechnical Engineering*, GSP 233, honors the technical contribution of Roy Olson, Ph.D., P.E., NAE, Distinguished Member ASCE. This Geotechnical Special Publication contains a total of 51 papers, 21 authored or co-authored by Prof. Olson along with 30 peer-reviewed contemporary, invited or submitted papers. Olson's early work dealt with clay behavior, consolidation analyses, and compaction of unsaturated soils. His later work focused on applications of soil behavior in foundation and forensic engineering including axial capacity of piles in sand and clay, pull out capacity of suction caisson foundations, and failures of excavations and bulkhead structures.

Contemporary innovations discussed in papers contributed to this volume include developments in consolidation analyses, modeling of shear strength, measurements of permeability, and interpretation of in-situ tests. Lessons learned from failures along with recent developments in foundation engineering such as characterization of energy piles, calculation of settlement from dynamic soil properties, developments in finite element modeling of foundations, mechanism of failure of jacked piles, mitigation of piling noise, and field load tests on a variety of foundations are also included.

*From Soil Behavior Fundamentals to Innovations in Geotechnical Engineering* contains practical and technical information on soil behavior fundamentals and current applications in geotechnical engineering that will be of interest to educators, researchers, and practicing geotechnical engineers.

(ASCE Press, 2014)



## Climatic Effects on Pavement and Geotechnical Infrastructure

**Edited by Liu, J., Li, P., Zhang, X. and Huang, B.**

Proceedings of the 2013 International Symposium on Climatic Effects on Pavement and Geotechnical

Infrastructure, held in Fairbanks, Alaska, August 4-7, 2013. Organized by University of Alaska (U.S.), Tongji University (China), Harbin Institute of Technology (China), Chang'an University (China), International Association of Chinese Infrastructure Professionals (IACIP), University of Tennessee (U.S.), and the Construction Institute of the American Society of Civil Engineers.

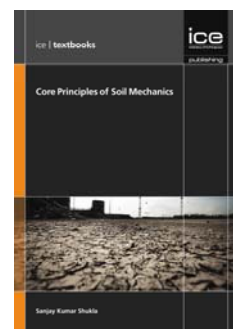
This collection contains 22 peer-reviewed papers that address the impact of various climatic factors such as freeze and thaw, wet and dry cycle, rainfall, and flooding on designing, building, preserving, and maintaining transportation infrastructure.

Topics include:

- international perspectives on climatic effects
- preservation, maintenance, and operations
- infrastructure materials and performance
- analysis and evaluation methods

This proceedings will be invaluable to professionals in pavement and geotechnical engineering including professors, students, design engineers, and contractors.

(ASCE, 2014)

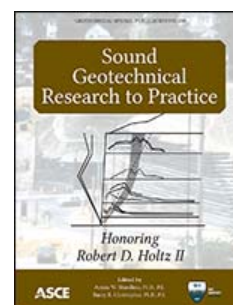


## Core Principles of Soil Mechanics - An ICE Textbook

**Sanjay Kumar Shukla**

*Core Principles of Soil Mechanics* presents an overview of the fundamentals of soil mechanics, drawing on optimum texts and including numerous illustrations and worked examples. Covers the essential topics of geological, basic, thermal and electrical characteristics; classification; stresses; fluid flow; consolidation; compressibility and shear strength.

(ICE, May 2014)



## Sound Geotechnical Research to Practice

Honoring Robert D. Holtz II

**A. W. Stuedlein and B. R. Christopher (editors)**

### Geotechnical Special Publications (GSP) GSP 230

*Sound Geotechnical Research to Practice*, GSP 230, honors Robert D. Holtz II, Ph.D., P.E., D. GE, Dist.M.ASCE, for his contributions to the geotechnical engineering profession in the areas of soft ground construction, reinforced soils, and fundamental soil behavior. In addition, Dr. Holtz has furthered education in engineering nationally and internationally and has made a significant impact building connections between industry and the academic community in the Puget Sound region of Washington.

This collection contains 39 papers that concentrate on applied geotechnical engineering research and practice in geosynthetics, laboratory testing, ground improvement, and reinforced soil walls, slopes, and embankments. Seventeen papers are reprints of works authored or co-authored by

Dr. Holtz, and 22 invited papers were contributed by colleagues from around the world.

*Sound Geotechnical Research to Practice* contains technical and practical information on soil behavior that will be of interest to educators, researchers, practicing geotechnical engineers, and contractors.

(ASCE Press, 2013)

## International Society for Soil Mechanics and Geotechnical Engineering



[http://www.issmge.org/attachments/article/648/ISSMGE\\_BULLETIN\\_Vol8\\_No1\\_Feb2014.pdf](http://www.issmge.org/attachments/article/648/ISSMGE_BULLETIN_Vol8_No1_Feb2014.pdf)

Κυκλοφόρησε το Τεύχος 1 του 8<sup>ου</sup> Τόμου του ISSMGE Bulletin (Φεβρουαρίου 2014) με τα παρακάτω περιεχόμενα:

- TC203 Chairman Message
- Report to ISSMGE Foundation
- NEWS ON RECENT CONFERENCES
  - 2nd Geotec Hanoi
  - IC of FEIIC, Saudi Arabia
- OTHERS
  - SEAGS Journal
  - From ICE Publishing
  - Event Diary
  - Corporate Associates
  - Foundation Donors
  - ISSMGE's International
  - Journal of Geoengineering Case Histories



[http://www.issmge.org/attachments/article/652/ISSMGE\\_BULLETIN\\_2014\\_April%20\(5\).pdf](http://www.issmge.org/attachments/article/652/ISSMGE_BULLETIN_2014_April%20(5).pdf)

Κυκλοφόρησε το Τεύχος 2 του 8<sup>ου</sup> Τόμου του ISSMGE Bulletin (Απριλίου 2014) με τα παρακάτω περιεχόμενα:

- Message TC 101 Chair
- New President of FedIGS
- Technical Article – 1 : Advanced Geomechanical Testing for Two Large Tunnelling Projects in Heavily Squeezing Conditions
- Technical Article – 2 : Railway Crossing the Bosphorus Strait – Realizing the 150-Year Turkish Dream of Connecting Asia and Europe
- Technical Article – 3 : Taoyuan International Airport Link Project in Taiwan
- NEWS ON RECENT CONFERENCES
  - Budapest, 2014
  - Belarus, 2013
  - Member News
- REPORT ON ISSMGE FOUNDATION
  - Geo-Congress, 2014
- OTHERS
  - Event Diary
  - Corporate Associates
  - Foundation Donors



## ISRM News Journal, Volume 16 - December 2013

The December 2013 issue of the ISRM News Journal is now available. It includes the ISRM activities in 2013, the Board and Council meetings, reports on the 2013 ISRM Field Trip and on the Eurock 2013 and Sinorock 2013 Conferences, a bio of the President-Elect 2015–2019 Dr Eda Quadros, a report of the Technical Oversight Committee on the work done by the Commissions, information on the publication of the "Orange Book" with the Suggested Methods 2007–2014, announcements of future events, reports of the Vice Presidents and many other articles of interest for the rock mechanics fraternity.

The ISRM News Journal is distributed to all members in electronic version. We still print a few copies of the News Journal, which are available at our sponsored symposia.

Click here to read it directly on our website or download it: <http://www.isrm.net/qca/?id=206>



International Society for Rock Mechanics

newsletter



## No. 25 - March 2014

[http://www.isrm.net/adm/newsletter/ver\\_html.php?id\\_newsletter=95&ver=1](http://www.isrm.net/adm/newsletter/ver_html.php?id_newsletter=95&ver=1)

Κυκλοφόρησε το Τεύχος 25 / Μάρτιος 2014 του Newsletter της International Society for Rock Mechanics. Περιεχόμενα:

- Welcome to EUROCK 2014 in Vigo, Spain
- ARMS8 - 2014 ISRM International Symposium, Sapporo, Japan, October 2014
- Online Lecture by Dr John Read, 10 April 2014, at 9:00am GMT
- Reservoir Geomechanics: a free online course by Mark Zoback, April to June 2014
- 13th International ISRM Congress, May 2015, Montreal: submit your abstract until 1 May 2014
- Volume 16 - December 2013 of the ISRM News Journal is now online



- Access to the Digital Library with OnePetro
- ISRM sponsored meetings
- ISRM Specialised Conference on Soft Rocks, Beijing
- 1st International Conference on Applied Empirical Design Methods in Mining, Lima, Peru
- VI Brazilian Rock Mechanics Symposium, September 2013
- ISRM training course held in Hanoi, Vietnam
- ISRM Vice President Ivan Vrkljan visited Hungary
- Professor Jean-Louis Briaud elected President of the Federation of International Geo-engineering Societies
- Inducing rockfalls in Norway - by helicopter



[www.geoengineer.org](http://www.geoengineer.org)

Κυκλοφόρησαν τα Τεύχη #108, #109 #110 και #111 του **Newsletter του Geoengineer.org** (Ιανουάριος, Φεβρουάριος-Μάρτιος, Απρίλιος και Μάιος 2014 αντίστοιχα) με πολλές χρήσιμες πληροφορίες για όλα τα θέματα της γεωμηχανικής. Υπενθυμίζεται ότι το Newsletter εκδίδεται από τον συνάδελφο και μέλος της ΕΕΕΕΓΜ Δημήτρη Ζέκκο ([secretariat@geoengineer.org](mailto:secretariat@geoengineer.org)).



**INTERNATIONAL TUNNELLING AND  
UNDERGROUND SPACE ASSOCIATION**  
ita@news n°53  
[www.ita-aites.org](http://www.ita-aites.org)

Κυκλοφόρησε το Τεύχος No. 53 – Μάρτιος 2014 των ita@news της International Tunnelling Association με τα παρακάτω περιεχόμενα:

- Message from Soren Degn Eskesen, ITA President
- WTC 2014 Open Session
- Latest news on WTC 2014
- Photo Contest- deadline 30th March
- News from Australia
- Meeting between ITA and TAI
- Workshop on Segmental Lining - New Dehli
- Workshop on Sprayed Concrete in Underground Structures - New Delhi.
- 15th Australasian Tunnelling Conference, 17th - 19th September 2014
- 2nd Eastern European Tunnelling Conference (EETC 2014)

- Fourth Mexican Congress on Tunnels and Underground Works from 8th to 10th October 2014, Mexico
- 12<sup>th</sup> International Conference Underground Infrastructure of Urban Areas, 22-23th October 2014, Poland



[http://www.itacet.org/Newsletter/18\\_2014/index.php](http://www.itacet.org/Newsletter/18_2014/index.php)

Κυκλοφόρησε το Τεύχος No. 18 (Απρίλιος 2014) του ITACET Foundation με τα παρακάτω περιεχόμενα:

- President's address
- Editorial Felix Amberg
- A word from Robert Galler new Chairman of the ITACET Committee
- ITA endorsed Master: Scholarship
- Next events in preparation
- Training session in Hanoi
- Training session in Shanghai

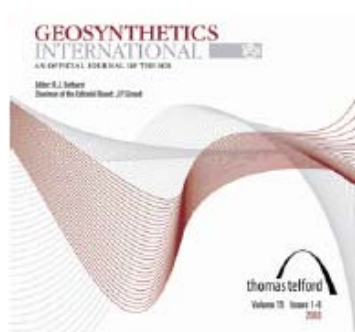


<http://origin.library.constantcontact.com/download/get/file/1111082143825-112/2014-03-igs-news-a8.pdf>

Κυκλοφόρησε το Τεύχος 1, Volume 30 των **IGS News**. Μεταξύ των θεμάτων περιλαμβάνονται:

- President's Corner: The IGS Elections
- General Information for IGS Members
  - Announcement of Candidates for: IGS Council,
  - President & Vice President – 2014 to 2018 Term
  - Candidate for the IGS President
  - Candidate for the IGS Vice-President
  - Candidates for the IGS Council
  - IGS Council Meeting Report for IGS News
  - Jean-Louis Briaud - Elected President of the Federation of International Geoengineering Societies (FedIGS)
  - Announcing the "International Geosynthetics Photo Contest 2014"
  - Feedback on Young IGS Members Operational Committee

- News from the Technical Committees of IGS
- Announcements of Conferences of IGS
  - 10th International Conference on Geosynthetics – 10ICG Berlin, Germany, 21 – 25 September 2014
- Announcements of Conferences under the Auspices of IGS
  - 7th International Congress on Environmental Geotechnics
- News from the IGS Chapters and the Membership
  - Honduran Chapter of the IGS
  - Vietnam Chapter of IGS (VIGS)
  - First National Conference on Geosynthetics in Honduras
  - 14th Portuguese Congress on Geotechnics
  - Short Report of Chinese IGS-Chapter's Seminar
  - International Conference on Advances in Civil Engineering for Sustainable Development
- List of IGS Chapters
- Official Journals of the IGS
  - Geosynthetics International
  - Geotextiles & Geomembranes
- Corporate Membership
  - Case studies – use the chance!
  - Case Study: New Drainage System for Tailings Storage Facility
  - Case Study: Soil Reinforcement at Cherry Island Land-fill
  - Case Study: Closure & Capping of Industrial Sludge Pond at Vishakapatnam, Andhra Pradesh
  - Case Study: Terramesh® Buttress Structure
  - Corporate Members of the IGS
  - Corporate Profile – GSE Environmental
- IGS News Publisher, Editor and Chapter
- Correspondents
- IGS Council
- IGS Officers
- IGS Membership Application
- Calendar of Events



## Geosynthetics International

[www.thomastelford.com/journals](http://www.thomastelford.com/journals)

Κυκλοφόρησαν τα τεύχη αρ. 1 και 2 του 21<sup>ου</sup> τόμου (Φεβρουαρίου και Απριλίου 2014) του περιοδικού **Geosynthetics International** με τα ακόλουθα περιεχόμενα:

### Volume: 21, Issue: 1

Brittle rupture of an aged HPDE geomembrane at local gravel indentations under simulated field conditions; F.B. Abdelaal; R.K. Rowe; R.W.I. Brachman

Laboratory characterisation of optimised geocomposites for asphalt pavement reinforcement; E. Pasquini; M. Bocci; F. Canestrari

Geosynthetic reinforcement of a granular load transfer platform above rigid inclusions: comparison between centrifuge testing and analytical modelling; Matthieu Blanc; Luc Thorel; Romain Girout; Márcio Almeida

An analytical method for calculating the natural frequency of reinforced retaining walls with soil-structure interaction effect; O. Abbasi; A. Ghanbari; S.A.A. Hosseini

Effects of blown film process on initial properties of HPDE geomembranes of different thicknesses; A.M.R. Ewais; R.K. Rowe

Creep behaviour of sand-geomembrane interfaces; H. Liu; J. Martinez

### Volume: 21, Issue: 2

Effects of EPS bead inclusions on stress-strain behaviour of sand; A. Edinçiler; A.T. Özer

Model tests on single and groups of stone columns with different geosynthetic reinforcement arrangement; K. Ali; J.T. Shahu; K.G. Sharma

Cationic starch flocculants as an alternative to synthetic polymers in geotextile tube dewatering; M.M. Khachan; S. K. Bhatia; R.A. Bader; D. Cetin; B.V. Ramarao

Diffusion of phenolic compounds through polyethylene films; M. Mendes; N. Touze-Foltz; M.dG. Gardoni; L. Mazéas

Overview of performance compatibility issues of GCLs with respect to leachates of extreme chemistry; A. Bouazza; W.P. Gates

Please find the download of the articles at:

<http://www.icevirtuallibrary.com/content/issue/gein/21/1>

<http://www.icevirtuallibrary.com/content/issue/gein/21/2>

For the IGS members to have FREE access to the papers they MUST log in through the IGS website.



## Geotextiles & Geomembranes

[www.geosyntheticssociety.org/journals.htm](http://www.geosyntheticssociety.org/journals.htm)

Κυκλοφόρησαν τα τεύχη αρ. 1 και 2 του 42<sup>ου</sup> τόμου (Φεβρουαρίου και Απριλίου 2014) του περιοδικού **Geotextiles & Geomembranes** με τα ακόλουθα περιεχόμενα:

### Volume: 42, Issue: 1

Probabilistic design of ground improvement by vertical drains for soil of spatially variable coefficient of consolidation; Md. Wasiul Bari, Mohamed A. Shahin

Improving piping resistance using randomly distributed fibers; A.R. Estabragh, K. Soltannajad, A.A. Javadi

Repeated loading of soil containing granulated rubber and multiple geocell layers; S.N. Moghaddas Tafreshi, O. Khalaj, A.R. Dawson

Measured and simulated results of a Kenaf Limited Life Geosynthetics (LLGs) reinforced test embankment on soft clay; S. Chaiyaput, D.T. Bergado, S. Artidteang

Interface shear characteristics of jute/polypropylene hybrid nonwoven geotextiles and sand using large size direct shear test; M.M.A. Sayeed, B. Janaki Ramaiah, Amit Rawal

Effects of prestressing the reinforcement on the behavior of reinforced granular beds overlying weak soil; Ramaiah Shivashankar, Jayamohan Jayaraj

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